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THE

MINERALOGICAL MAGAZINE

AND

Journal of

The Mineralogical Society.

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ASSISTED BY A COMMITTEE OF COUNCIL.

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1910.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, January 25, 1910, *at* 5 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., President, in the Chair.

Professor E. S. Fedorov was elected an Honorary Member, and Miss Mary Winearls Porter an Ordinary Member of the Society.

Dr. G. F. Herbert Smith and Mr. F. H. Butler were elected Auditors for the accounts of the year ending December 31, 1909.

The President, the General Secretary, and the Editor of the Journal, in conjunction with Mr. L. Fletcher and Principal H. A. Miers, were appointed Editorial Committee for the Journal.

GENERAL MEETING.

Held in the Apartments of the Geological Society, January 25, 1910, *at* 5.30 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., President, in the Chair.

Twenty-six Members and two Visitors were present.

The elections of Professor E. S. Fedorov as Honorary Member and of Miss M. W. Porter as Ordinary Member were confirmed.

The following papers were read:—

1. On a group of minerals formed by the combustion of pyritous shales in Midlothian: by Dr. S. J. Shand (p. 403).

2. A crystal-holder for use in measuring large specimens: by Prof. W. J. Lewis.

3. Some observations on pleochroism: by Mr. T. Crook.

4. Notes on the weight of the 'Cullinan' diamond, and on the value of the carat-weight: by Mr. L. J. Spencer (p. 318).

5. On a basalt from Rathjordan, Co. Limerick: by Dr. G. T. Prior (p. 315).

6. On a fluo-arsenate from the Indian manganese deposits: by Dr. G. F. H. Smith and Dr. G. T. Prior.

7. The composition of a stone from the meteoric shower of Dokáchi: by Prof. H. L. Bowman and Mr. H. E. Clarke.

Specimens of synthetical sapphire were exhibited by Dr. G. F. Herbert Smith, and pseudomorphs of pleonaste after corundum from Ceylon by Mr. T. Crook.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, March 15, 1910, *at* 5 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., President, in the Chair.

The resignation of Mr. A. Pringle was accepted.

Mr. Donald Alexander MacAlister and Mr. Walter Campbell Smith were elected Ordinary Members of the Society.

The audited Balance-sheet for the year ending December 31, 1909, was submitted and approved.

Mr. Spencer reported that he has prepared, on behalf of the Society, 1033 slips relative to Mineralogical, Crystallographical, and Petrographical papers and books published in the United Kingdom during 1909, for the International Catalogue of Scientific Literature.

A hearty vote of thanks to Mr. Spencer for his work in preparing slips during the last ten years was carried.

GENERAL MEETING.

Held in the Apartments of the Geological Society, March 15, 1910, *at* 5.30 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., President, in the Chair.

Thirty-three Members and two Visitors were present.

The elections of Mr. D. A. MacAlister and Mr. W. Campbell Smith to the Ordinary Membership were confirmed.

The following papers were read:—

1. A new form of petrological microscope; with notes on the illumination of microscopic objects: by Mr. G. W. Grabham (p. 335).

2. On Datolite from the Lizard district, Cornwall: by Mr. W. F. P. McLintock (p. 407).

3. Additional notes on zeolites from Cornwall: by Mr. Arthur Russell (p. 377).

4. A modification of the stereographic projection: by Dr. J. W. Evans (p. 401).

5. Axes of rotatory symmetry: by Dr. J. W. Evans (p. 398).

Models of space-lattices and regular point-systems were exhibited by Professor H. L. Bowman.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 7, 1910, *at* 5 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., President, in the Chair.

Dr. Frederick Henry Hatch was elected an Ordinary Member of the Society.

Resolved to nominate Messrs. T. V. Barker, J. M. Gordon, R. Pearce, and H. H. Thomas in place of the four retiring members of Council (Messrs. W. Barlow, B. Kitto, A. Russell, and G. F. H. Smith).

A letter from Professor E. S. Fedorov on his election to the Honorary Membership of the Society was read.

A letter was read from the President and Secretaries of the Geological Society, enclosing an appeal to H. M. Treasury for a reduction in price of the hand-coloured maps issued by the Geological Survey. Resolved that the appeal receive the support of the Mineralogical Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 7, 1910, *at* 5.30 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., President, in the Chair.

Twenty Members and two Visitors were present.

The election of Dr. F. H. Hatch to the Ordinary Membership was confirmed.

The following papers were read:—

1. On the occurrence of Phenacite in Cornwall: by Mr. A. Russell.
2. Phacolite from near Belfast: by Dr. G. F. H. Smith.
3. Crystalline form of nitrogen sulphide: by Dr. G. F. H. Smith.
4. On a new arsenate and phosphate of lime and strontia from the Indian manganese deposits: by Dr. G. F. H. Smith and Dr. G. T. Prior.
5. A (fifth) list of new mineral names: by Mr. L. J. Spencer (p. 415).

Mr. C. R. Lindsey exhibited specimens of brookite showing lamellar twinning from Switzerland, and twinned crystals of quartz from Brazil.

MINERALOGICAL SOCIETY.

ABSTRACT OF RECEIPTS AND PAYMENTS FROM JANUARY 1 TO DECEMBER 31, 1909.

Receipts.	£ s. d.	£ s. d.
Balance from 1908		37 17 10
Subscriptions—(1) current	51 8 0	
(2) arrears	5 5 0	
		56 13 0
Entrance fees and Compositions		19 19 0
Sale of publications—		
By Publishers	26 4 6	
By G. Savigar	10 3 5	
		36 7 11
Dividends on Stock		19 2 7
Grant from Royal Society Publication Fund (for Dr. Sorby's paper)		10 0 0
		£180 0 4

Payments.	£ s. d.	£ s. d.
Printing Magazine (No. 70)	27 4 4	
Authors' copies	3 19 3	
		31 3 7
Miscellaneous Printing		6 14 1
Editor's Honorarium (1908)		10 10 0
G. Savigar for care of stock of Publications (1908)		1 1 0
Porter's Fee		1 5 0
Postage and Parcels—		
Printers (Magazine)	1 12 6	
,, (Authors' copies)	3 5	
G. Savigar (1908)	4 6	
Hon. Secretary (1908)	7 5	
Hon. Treasurer (1908)	9 3	
		2 17 1
Investments		69 2 7
Bank Charges		0 1 0
Book-binding		5 0 0
Balance at Bank	49 9 11	
,, in Office	2 16 1	
		52 6 0
		£180 0 4

Examined and compared with the vouchers, and found correct.
17 *February*, 1910.

(*Signed*) FRANCIS H. BUTLER, G. F. HERBERT SMITH } Auditors.

Liabilities.	£ s. d.	Assets.	£ s. d.	£ s. d.
Owing for Miscellaneous Printing	1 4 6	Balance at Bank		49 9 11
,, for Editor's Honorarium (1909)	10 10 0	,, in Office		2 16 1
,, G. Savigar for care of stock of Publications (1909)	1 1 0	Consols (£832 5*s.* 10*d.*, valued at £82½)		686 10 0
,, Do. for postage (1909)	3 3	Sale of Publications—		
,, Hon. Secretary for postage (1909)	12 6	Owing from Publishers	19 3 0	
,, Hon. Treasurer ,, ,, (1909)	7 7	,, G. Savigar	2 0 11	
Excess of assets over liabilities	746 1 1			21 3 11
	£759 19 11			£759 19 11

The stock of Publications and the value of the Library are not

THE MINERALOGICAL MAGAZINE

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THE MINERALOGICAL SOCIETY.

No. 72. SEPTEMBER, 1910. Vol. XV.

An improved form of petrological microscope: with some general notes on the illumination of microscopic objects.

(*With Plate VIII.*)

By G. W. Grabham, M.A., F.G.S.

Geologist to the Sudan Government.

[Read March 15, 1910.]

Introductory.

IT is more than twenty-one years since Mr. Allan B. Dick communicated a description of the microscope, now generally associated with his name, to this Society.[1] The instrument is familiar to all mineralogists, and it will suffice to say that the main feature consisted in having the polarizing and analysing prisms arranged so that they can be rotated simultaneously, instead of turning the object on the stage between them. The rotating stage is never very satisfactory, especially when it is desired to examine minute crystals in convergent light. In two pamphlets,[2] published later, Mr. Dick extended his description of the instrument and gave some methods of using it. He intended the microscope as a 'Student's instrument' suitable for work in all branches of science, and, with this view, he desired to fix its

[1] A. B. Dick, 'A new form of microscope.' Mineralogical Magazine, 1889, vol. viii, pp. 160–163.

[2] A. B. Dick, 'Notes on a new form of polarizing microscope,' London (J. Swift & Son), 1890. 'Additional notes on the polarizing microscope,' London (J. Swift & Son), 1894.

type in not too expensive a form. How well he succeeded in this may be judged from the fact that hardly any change has taken place during all the years that have elapsed. The most important improvement consists in fitting a condenser with an aperture suitable for use with immersion-lenses. The price of the small model, complete with lenses, amounts to close on £30, and would now appear to place it quite beyond the range of 'Student's instruments'.

The main defect of the instrument as placed on the market lies in the condenser fittings. The top lens of the system is fitted in a bar sliding in the stage, while the lower part is fixed to the top of the polarizer fitting, or placed in a mount that enables us to focus the condenser. The lens in the sliding bar is very liable to get scratched, while the other lenses are difficult to remove from the axis when it is desired to use parallel illumination. The use of immersion fluids is attended with a good deal of mess, and, unless the stage is carefully cleaned afterwards, the sliding bar may become clogged.

Another model embodying Mr. Dick's principle, but possessing different sub-stage arrangements, was brought out a few years ago by Messrs. R. & J. Beck under the name of 'The London petrological microscope'. The condensers could be focused by means of a rack and pinion, while the top lens of the system, instead of sliding in the stage, was pivoted so that it could be swung out of the axis when not required. The whole condenser could be removed, but the change from convergent to parallel illumination was not effected with the ease desirable in petrological studies. The arrangements were better suited for the use of immersion fluids; but practically no advantage was gained, as the aplanatic cone of the condenser was only 1·0 N.A. and consequently unable to fill the ordinary objective of about 1·3 N.A. when examining minerals in convergent polarized light. The stand was of the continental type and very heavy.

In one of his pamphlets on the microscope[1] Mr. Dick stated that more costly forms of the instrument had been made in which the stage rotates, the sub-stage can be centred and is moved up and down by rack and pinion, while the condenser and polarizer swing, separately or together, out of or into the axis of the instrument. For ordinary work he did not consider that there was any advantage in these appliances, though for special work they are desirable. No figure appears to have been given of this instrument and it was not placed on the market.

[1] A. B. Dick, 'Additional notes,' (1894), preface.

The New Model.

When ordering a microscope for the Sudan Government, it occurred to me that the ordinary form of Dick's microscope was capable of improvement, and I desired an instrument in which the sub-stage permitted:—

(1) of an easy change from parallel to convergent illumination by having the condenser systems mounted so that they could be removed from or introduced into the axis of the instrument at will:

(2) the use of any condenser within the limits of the 'universal thread'.

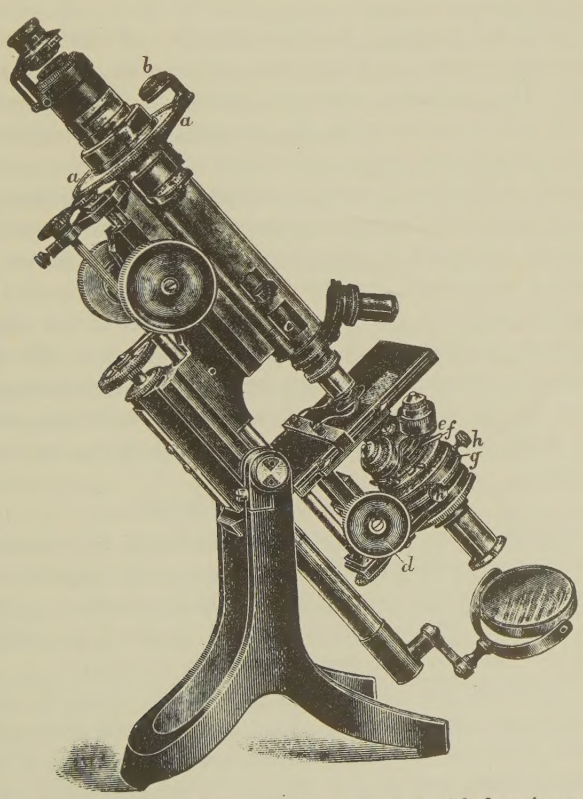


Fig. 1.[1]—Improved form of Mr. Dick's microscope with focusing sub-stage.

[1] The block for this figure has been kindly lent by Dr. A. E. H. Tutton, F.R.S., with the permission of Messrs. Macmillan & Co., Ltd., the publishers of his forthcoming book on crystallography.

These requirements were effected in a very simple way by placing the polarizer on a focusing sub-stage with a nose-piece to carry the condenser systems. The latter idea was taken from an instrument designed by Dr. J. S. Flett and built for the petrological department of H.M. Geological Survey. In the ordinary model means are provided in the shaft, which connects the analyser and polarizer, for taking up movements due to focusing of the objectives, and these means were adapted to take up those due to the focusing movements of the sub-stage as well.

Suggestions on these lines were put into the hands of Messrs. J. Swift and Son, who worked out the mechanical details and produced the instrument shown in fig. 1.

Mineralogists are generally familiar with the ordinary model, and it is therefore unnecessary to say more than a few words about the present instrument. The graduated circle (*a*) instead of being placed below the stage is now connected with the eye-piece and this obviates any play, due to cog-wheels, between the cross-wires and the graduations. The sub-stage is fitted with centring screws (*h*), an iris-diaphragm (*f*), and means of introducing coloured screens or stops for oblique illumination. A triple nose-piece is convenient, as this allows the use of high and low-power condensers, besides leaving an empty nozzle through which parallel light can pass freely along the axis of the microscope. The instrument is figured with a second analyser in a sliding fitting (*c*) just above the objective. This has been added for photographic purposes, but if the full advantage of it is to be gained there should be a rotating stage to enable the worker to orientate his section in the polarized light.

Illumination of the Object.

A few remarks on the subject of illumination may not be out of place here, since the new model gives the worker a greater scope for variation than do some of the older forms of petrological instrument. There are numerous textbooks on the microscope that deal with the subject, but any that I have seen treat it merely from the standpoint of obtaining the finest definition and the greatest resolution. They do not, as a rule, consider the nature of the object and the rôle that differences in refractive index, either in the object itself or between it and the surrounding medium, may play in helping us to understand its constitution.[1] In mineralogical studies the microscope is used not merely as

[1] The matter, however, is referred to both by E. Weinschenk in his 'Anleitung zum Gebrauch des Polarisationsmikroskops' (2nd edit., Freiburg i. B., 1906), and by H. Rosenbusch and E. A. Wülfing in their 'Mikroskopische Physiographie der petrographisch wichtigen Mineralien' (Stuttgart, 1904).

a means of magnifying objects, but for the purpose of distinguishing between substances of different optical properties, and we generally have to make use of these differences to enable us to recognize the form of the various constituents of the object under examination.

Textbooks on microscopy tell us of the importance of seeing that the back lens of the objective is properly filled with light, and the evils attending the use of narrow cones are duly emphasized.[1] We are, however, left quite in the dark as to the defects of such illumination when used in the study of objects composed mainly of anisotropic substances. Good 1-inch and $\frac{2}{3}$-inch objectives of 0·3 N.A., such as are commonly employed in the study of rock-sections, include an angular cone of light of about 20° in a mineral such as quartz, and it is obvious that if the birefringence of our object is at all marked, there may be considerable differences in the retardation and interference-colours produced in the various parts of even such a narrow cone.

If we place a section of fairly coarse-grained marble on the stage, focus it, and so adjust the illumination that the back lens of our 0·3 N.A. objective is filled with light, then examine this with the analyser in position, we see that the light transmitted by a single crystal is not uniform, but is variously coloured. The cone of illumination may, in fact, include one of the bars of the uniaxial figure, part of which may in consequence be observed by suitable methods. Such is the assortment of variously retarded rays that the eye-piece is presented with for the formation of the image when using the full aperture of our low-power objective, and it will be readily understood that the interference-tints are much paler in consequence. If we close the iris-diaphragm, and thus reduce the angle of the cone of light admitted to the objective, the interference-colours become very much brighter in the case of calcite, and there is a distinct difference in the case of a less strongly birefringent mineral such as olivine. The colours obtained as a result of using a cone of light often simulate those of a different order from that which would be

[1] The following quotation from Dr. E. J. Spitta's excellent book, 'Microscopy,' London, 1907, p. 177, will serve as an example: 'For example, bacteriologists seem mostly agreed that the bacillus tuberculosis is probably not an organism likely to have a capsule under ordinary conditions, and yet with a narrow cone, whether the specimen be stained or unstained, a very pronounced encircling capsule, as bright and clear as possible to the eye, appears in *every case*; yet, as the cone is steadily and slowly increased, so does this mysterious capsule disappear.' To the mineralogist, familiar with Becke's white-line effect, such a phenomenon offers no difficulty, and indeed is often sought for as a means of diagnosis. It is clear, however, from the sections dealing with polarized light that our author is not very familiar with the use of the microscope in petrology.

obtained with parallel light. The ordinary rock-slice, as now prepared, is about 0·015 mm. in thickness (olivine showing straw- to reddish-yellows) and the carbonates show colours of the third to fourth order in parallel light, but with a cone of 0·3 N.A. the tints become so pale that they might in some cases be mistaken for white light of the higher orders.

An experiment with oblique illumination may help to remove any remaining doubt as to the undesirability of filling the back lens of the objective with light if the interference-colours are to be examined. A suitable stop is placed in the fitting provided for the purpose so that only an oblique beam is admitted to the objective, forming a bright spot on the periphery of its back lens. Such a stop, in the form of a cardboard disc with a hole about $\frac{1}{8}$-inch from the centre, can easily be prepared for the purpose; those provided by the makers may prove to be unsuitable when such a narrow cone of light is in use. Now, replacing the eye-piece and examining the slice of marble between crossed nicols, each grain of calcite shows different colours according to the direction in which the beam happens to be traversing the crystal. By rotating the stop we can alter the direction and, as we do so, the interference-colours are changed. In this way it is possible to produce an almost kaleidoscopic effect without turning the nicols or moving the specimen—simply by rotating a stop with an eccentric aperture beneath the condenser. These changes are due to the fact that we are using different portions of the optic figure, as seen in the back of the objective, for each particular grain, and this will vary according to the crystallographic direction in which it happens to be cut. If a section is chosen that gives a figure in the back lens of the objective such that the optic axis is just beyond its limits and the nicols are placed so that one of the bars lies across the field, it will be understood that our eccentric stop only admits a beam corresponding to a small portion of the periphery of the figure. As the direction of the beam alters, the colours may change from white of the first order to orange of the second order, and the section will actually extinguish in two directions of the beam, owing to the optic axial bar that crosses the field.

If convergent light is used, it is only possible to obtain good compensation by means of the quartz-wedge when the mineral has comparatively low double-refraction.

The study of pleochroism does not appear to be affected to the same extent as that of the interference-colours by the use of convergent light, and this, no doubt, is due to the fact that it depends on the direction

of the vibrations and not so much on the path of the rays in the crystal. If, however, the optic axis of a strongly pleochroic mineral lies just within the angular field of the objective, a marked difference of colour can be seen, due to the plane-polarized light traversing the mineral as the extraordinary ray in one part of the cone and as the ordinary ray in another. The same sort of thing occurs in the case of sections almost perpendicular to the optic axis in a biaxial crystal, and there can be no doubt that it must be better to avoid the possibility of these effects by using parallel light for the examination of pleochroism. If we use convergent illumination, the image of the crystal is built up of a mixture of differently affected rays which drown the normal result.

Refractive Index of the Object.

The necessity of using parallel illumination for the examination of refraction has always been realized, and in the ordinary model the nearest approach to this is obtained by lowering the condenser-lens and closing the iris-diaphragm. This involves some loss of light, and it is far better to be able to throw the condenser out of the axis, as we are able to do in the new model. To the practised eye refractive index is a most important guide in the distinction of minerals, and as convergent light tends to obliterate the effects due to it, workers using such illumination may be misled, unless they continually reduce the cone by means of the iris and so check their observations.

The expression 'parallel illumination' is used here, as elsewhere in this paper, in contradistinction to convergent illumination and not in the strict sense of the term. For ordinary purposes a cone of from 5° to 10°, only filling about half the back lens of the objective, is sufficiently narrow to give good results. This can be obtained either with a condenser or directly from a source of light, such as a window, which subtends about that angle. The latter always seems to me to be the most comfortable to work with; it appears to give more light, as well as rendering differences of refraction clearer, than a similar cone produced with the aid of the condenser.

The White-Line Effect.

The ordinary explanation of Becke's white-line effect involves the use of convergent light, though it is explained[1] that too large a cone will

[1] H. Rosenbusch and E. A. Wülfing, 'Mikroskopische Physiographie der petrographisch wichtigen Mineralien,' Stuttgart, 1904, vol. i, pt. 1, p. 263. I have not been able to refer fully to the original papers, but a full account of them appears to be given in this textbook, which includes references to the work of other authors bearing on the white-line effect, notably W. Salomon and C. Viola.

drown it, and practically the only case considered is that in which the line of junction is normal to the plane of section, as shown in fig. 2.

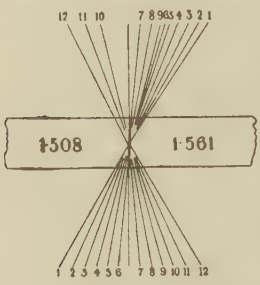


Fig. 2.—Old explanation of the white-line effect.

In practice, however, we make use of the nearest approach to parallel light that our instruments admit of, and as a line of junction normal to the plane of section must be extremely rare, we must seek some modification of the explanation usually given. Mr. E. M. Anderson, of H.M. Geological Survey, pointed this out to me some years ago, and I am very much indebted to him for permission to introduce the following explanation which is on the lines of the one he gave me.

If the junction of the minerals is inclined to the plane of section, we are at once presented with two cases according as the more highly refracting or the less highly refracting medium overlaps the other. In

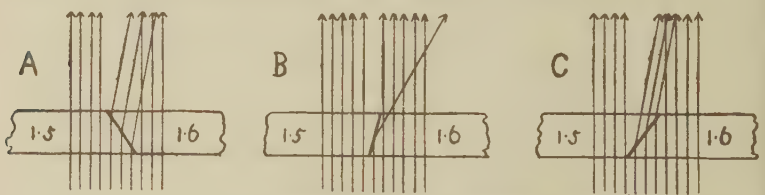


Fig. 3.—New explanation of the white-line effect.

the first case, shown diagramatically in fig. 3 A, rays normally incident on the section enter the denser medium at the inclined junction and are bent towards it. In the second case, the rays, on reaching the less dense medium, are either totally reflected back into the denser one, fig. 3 B, or they are refracted towards it on traversing the junction as shown in fig. 3 C. In whatever direction the junction happens to be inclined, a beam of light on traversing it is always bent towards the more highly refracting substance.

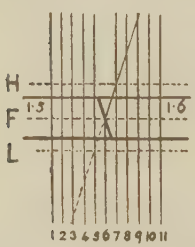


Fig. 4.—New explanation of the white-line effect.

This, however, does not entirely explain the white line seen parallel to the junction when the microscope-tube is either slightly raised or lowered, but it will be made clear on referring to the diagram, fig. 4, where rays of light, numbered 1–11, are shown traversing a section containing an inclined junction between two minerals of different refractive index. Ray 6 meets the junction and is

bent towards the more highly refractive medium on the right, while the rest of the rays traverse the section without being bent. If the focal-plane of the objective lies in about the position of the dotted line *F*, the section appears in focus and no white line is seen at the junction. When the microscope-tube is raised, so that the focal-plane occupies the position *H*, a white line is seen on the side of the more highly refracting mineral; this is due to the fact that rays 6 and 7 are combined and brought to a focus as if they originated in their crossing point which lies on the focal-plane. If the tube is still farther raised, the point at which ray 6 meets the focal-plane moves on to the right and it is combined successively with rays 8 and 9, so the white-line effect becomes more remote from the junction. When, on the other hand, the microscope-tube is lowered, so that the focal-plane of the objective assumes the position *L*, the white line is produced by the combination of the deviated ray 6 with ray 5, as if they originated at a point in the focal plane. The position of this point is where the trace of the deviated ray would cross ray 5 if produced backwards as shown by the dotted line in the diagram. If we continue to lower the tube, the white line shifts to the left, as it is due to the successive combinations of 6 with 4 and 6 with 3 The inversion of the image by the microscope does not affect this explanation.

The case of a junction perfectly normal to the plane of section is probably very rare, but with ordinary methods of illumination a certain amount of light would meet it obliquely and be deviated towards the denser medium after the manner shown by Becke (fig. 2).

We may now apply these conclusions to a special case, and for the sake of simplicity choose contiguous sections of the mineral quartz, one cut normally to the optic axis and the other parallel to it. The light transmitted by one section is subjected to a retardation corresponding to the ordinary ray, while it may vary in the other section between limits corresponding to the refractive indices $\omega = 1{\cdot}5442$, and $\epsilon = 1{\cdot}5533$, according to the direction of vibration. If we set the polarizer so that the plane of vibration is parallel to the optic axis, we get the greatest difference between the retardations in the two sections, $\epsilon - \omega = 0{\cdot}0091$, since the beams transmitted by the two sections correspond to the ordinary and extraordinary rays respectively.

The effects of variously inclined junctions between two such sections are easily calculated and the results for a series ranging from an inclination of 60° towards the less dense to 60° towards the denser medium have been carefully plotted. In the diagram, fig. 5, the denser medium is always supposed to lie on the right-hand side of the junction

and, in each individual case, the inclination of the junction and the deviation produced by it in a ray normally incident on the section are given. It is seen, beginning at the left of the diagram where the denser medium overlaps the less dense with the junction inclined at 60°, that the amount of deviation increases until the junction becomes normal to the plane of section. After passing the normal position, we have the less dense medium overlapping the other and the deviation, now due to total reflection, begins at zero and increases fast until the critical angle is reached at 83° 48′; it then falls immediately from over 12° to about 6°

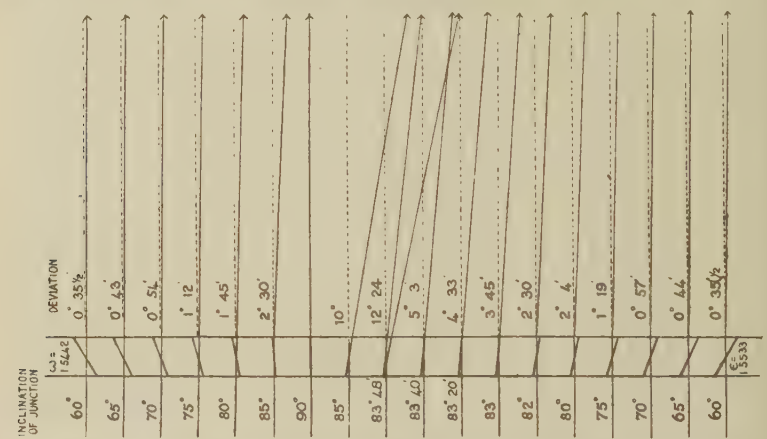


Fig. 5.—Deviations of rays at variously inclined junctions of quartz crystals.

and afterwards decreases rapidly, so that a junction inclined at 60° produces about the same amount of deviation whichever way it happens to lie.

In the case under consideration, the difference in retardation between the ordinary and extraordinary rays, though comparatively small, is enough to give a pronounced white-line effect; and it appears that a very small amount of deviation is sufficient to produce it, certainly less than half a degree in amount. We have seen that the deviation varies considerably, and with contiguous quartz crystals may amount to over 12°. This is sufficient to throw the beam outside the limits of an ordinary low-power objective and leave the junction dark, if it were illuminated by strictly parallel light. The best white-line effect is no doubt produced when the deviation is well marked.

A practical application of the principles involved can be made in the comparison of mediums of closely similar refractive index, or, where the junctions are few and bad, by the use of oblique illumination. It is

obvious that, if we can make use of a beam incident in the vicinity of the critical angle, the delicacy of the test may be greatly increased. This can be done by using a condenser with a small movable stop beneath. It might be desirable to have a special fitting to enable the stop to be traversed across the condenser in every direction, but the expense of such a refinement is hardly justified by the amount of use likely to be made of it. With the aid of an eccentric stop in the rotating fitting beneath the stage we can obtain, without much trouble, any incidence of which the condenser is capable.

If, in addition to restricting the illuminating cone, a stop is introduced above the section, the reaction of the junction can be made very clear by cutting out either the direct light passing through the section alongside it or the deviated beam. A stop may be introduced for the purpose in any one of three positions. Either of the positions immediately above the eye-piece or below the objective is convenient, because the stop and section are seen in their proper relations to one another. The third position, just above the objective, is not so convenient, as the image of the object is reversed, while that of the stop is not, and consequently it appears to act in the reverse way to those introduced either below the objective or above the eye-piece. A piece of apparatus, known as a refractometer, designed in 1885 by Exner, may be used to stop out part of the emerging pupil above the eye-piece, but for ordinary purposes a piece of card or stout paper is quite serviceable. A stop placed just in front of the objective seems more effective, as the rays are spread farther apart in this position; but it is necessary to place it above the eye-piece in the case of high-power objectives, which do not admit of any stop being used between their front lens and the object.

The rays of light passing through the junction of two minerals are deviated towards the denser, and it may easily be remembered that the more highly refracting minerals stand out with a light margin towards the stop and a dark one away from it. In illustration of this the photographs in Plate VIII have been taken. They were done by an ordinary microscope fitted with an eye-piece and a 1-inch objective. The stop took the form of a wire, 0·74 mm. in diameter, placed just in front of the objective, and appears as a broad bar across the picture. The line at right angles to it is the image of one of the cross-wires of the eye-piece. The illumination was in the form of a cone as narrow as was compatible with a reasonable exposure and small enough to allow the stop to appear clearly. It was provided by focusing the image of a

flame on a small hole in a diaphragm placed near the focus of a lens which projected the light along the axis of the microscope. The stop subtended an angle of about $3\frac{1}{2}^\circ$ at a point in the focal-plane of the objective, for this had a working distance of 12·5 mm. and the wire was immediately in front of it. Knowing this angle, it appears that the cone of illumination had an even smaller one, for the stop would have been obliterated had the angle of the cone exceeded 2°. A polarizer was placed in the axis and the vibration-direction was adjusted in each case so as to show the differences of refractive index most clearly.

Photographs Nos. 1 and 2 show the junction of two quartz crystals: in the first, the direct light is cut off from its neighbourhood; while in the second the junction appears dark, owing to the deviated rays being intercepted while the direct light passes. The photographs are sufficiently sharp to show the varying inclinations of the junction by its differences in breadth. The next two photographs are of a quartz-mosaic. In No. 3 the section is in focus and the more highly refracting grains stand out along both sides of the stop; but in No. 4 the microscope-tube has been raised slightly and the white-line effect is seen just inside the margins of the more highly refracting grains all over the field of view. The actual boundaries appear as black lines because the deviation of the ray has left them in darkness. No. 5 is another view of a quartz-mosaic, and here, as in No. 3, the highly refracting grains are seen standing out along the sides of the stop. In both cases the varying inclinations of the junctions are indicated by the different breadths of the light and dark lines. The dark patches towards the margins are due to the presence of cloudy felspar.

No. 6 shows a plagioclase crystal cut nearly perpendicularly to the brachypinacoid, so that the conditions are favourable to the production of considerable deviations at the junctions of the twin-lamellae, and consequently some of their boundaries are clearly seen right across the bar.

If substances differ much in refractive index the rays passing through the junction may be deviated quite beyond the scope of an ordinary low-power objective, but they can often be caught by one of larger aperture. It is, therefore, an advantage to have objectives of large aperture even though the cone of illumination be restricted.

Becke[1] has pointed out the fact that the white-line effect is less distinct if the mineral section is embedded in a medium of markedly lower refractive index. The same may be said of a medium with a markedly

[1] H. Rosenbusch and E. A. Wülfing, loc. cit., p. 266.

higher refractive index, as in both cases a good deal of dispersion takes place at the surfaces of the section and this tends to mask the deviated rays. It is, therefore, important to have the section mounted in a substance of about the same index as those of the minerals it is desired to compare.

Suggestions for Further Improvements in the Design of the Microscope.

The use of the instrument described in the first part of this paper shows that there is still something left to be desired.

The field of view, as in the older model, is small when compared with that of an ordinary microscope. This, I believe, is mainly due to the fact that the nicol is placed above the eye-piece instead of being as close as possible to the objective. There does not appear to be any practical difficulty in altering the position of the prism, and in fact it has already been done in an instrument made by Messrs. Voigt and Hochgesang of Göttingen. It would probably be best to enclose the nicol-carrier in a large body-tube, the whole of the inside of which would rotate with the eye-piece. Provision must, however, be made for the insertion of the quartz-wedge, &c., between the nicols.

The gearing which connects the analyser and polarizer is open to objection because the vertical shaft restricts the size of the stage, unless a train of cog-wheels larger in size than those generally provided is used at each end to connect with the nicols. It has been objected that, even with the best workmanship, there is sufficient back-lash to vitiate some observations between crossed nicols. Practically the whole of this back-lash can be made to compensate itself if the motion is imparted to the vertical shaft, when the lags in the trains of wheels equalize one another. It appears that a milled head has been provided in some instruments for this purpose. If a flexible shaft could be made use of to connect the nicols it would obviate the necessity for trains of cog-wheels and allow the use of a larger stage. Flexible shafts are composed of two spirals, wound in opposite directions one inside the other, and are only meant to be used in that direction of rotation which compresses them together by tending to unwind the inner and wind up the outer spiral. For our purpose it is necessary to have a fairly rigid shaft capable of rotation in either direction, and this might be attained by the use of three spirals, so that the central member would tend to press

either against the inner or the outer one according to the direction of rotation. I do not know whether such a device would be sufficiently rigid to be of practical use, but no doubt it would be worth a trial.

A mechanical stage capable of rotation is very useful, and might be fitted to the instrument if the nicols were connected by means of a flexible shaft. It would be an additional advantage if the stage could be unshipped from the brackets, so as to admit of the use of a goniometer. If the stage does not rotate, it should be of the horse-shoe form, as this is convenient when using immersion liquids.

In conclusion, I do not apologize if ground has been traversed that has been dealt with by others before, as this paper has been written in Khartoum where no mineralogical library exists. If such investigations have been made, they do not appear to be referred to by the standard textbooks which I have at hand.

It is with pleasure that I record my indebtedness to Dr. J. S. Flett, of H.M. Geological Survey, for the way in which he superintended the construction of the instrument and helped me in the selection of lenses, &c. As a colleague I worked under his guidance at Jermyn Street in London, and learnt something of his practical improvements in the design of petrological microscopes. To Messrs. J. Swift and Son, the makers of the instrument, I am indebted for the skill with which the design was carried out and its details modified as necessity arose.

Finally, I take the opportunity of again recording my thanks to my former colleague, Mr. E. M. Anderson, in connexion with the explanation of the white-line effect which he has so kindly allowed me to introduce.

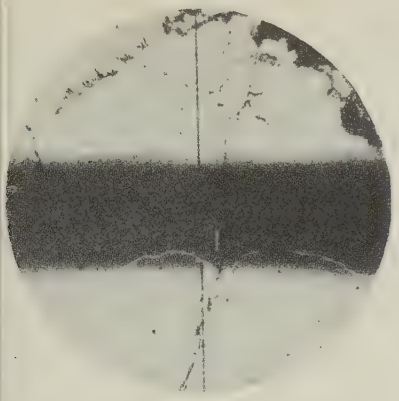
EXPLANATION OF PLATE VIII.

(All the figures are magnified 30 diameters.)

Fig. 1. Junction of two quartz crystals. The direct light is cut off by the stop and the junction appears light on a dark ground. Rannoch Muir granite, ¾ mile south-south-west of Kingshouse, Glencoe, Argyllshire.

„ 2. The same junction as in fig. 1, but the deviated ray is cut off, so that the junction appears dark on a light ground.

„ 3. Quartz-mosaic, which shows the more highly refracting grains standing out along the margins of the stop, with light margins towards it and dark ones away from it. Pegmatite-vein in gneiss, Glen Mor, Glenelg, Inverness-shire.



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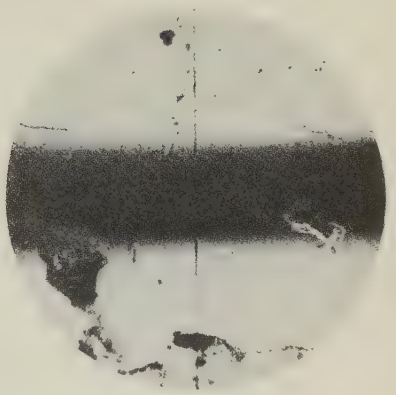

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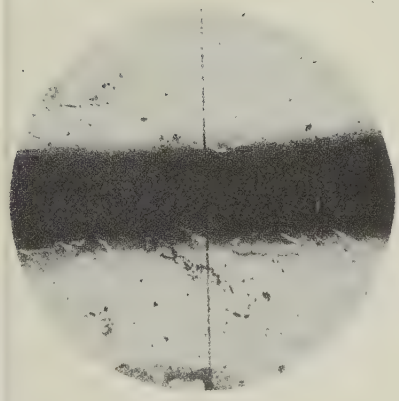

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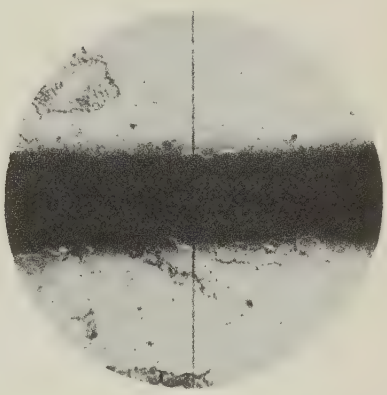

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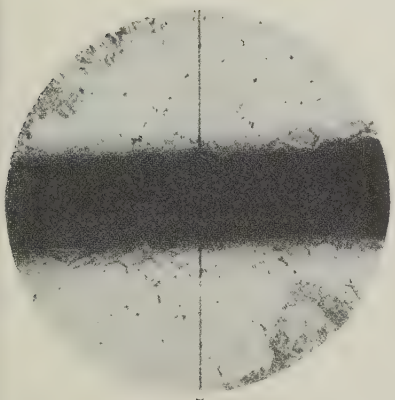

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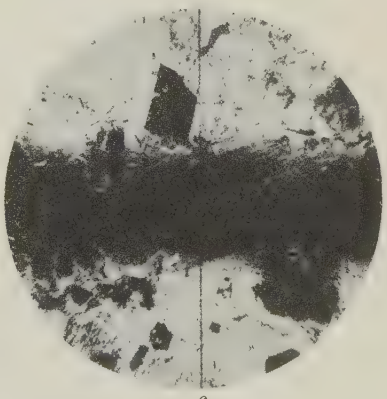

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G. W. Grabham: Illumination of Microscopic Objects.

Fig. 4. The same section, but as the microscope-tube has been raised it is not in focus. The white-line effect, just inside the margins of the more highly refracting grains, is seen all over the picture, while the actual junctions of the grains appear as dark lines.

,, 5. Quartz-mosaic, showing highly refracting grains standing out along margins of stop. The varying inclinations of the junctions are clearly indicated by the different widths of the light and dark margins. Different part of same slide as in fig. 3.

,, 6. Twinned felspar. The junctions of the albite-lamellae are shown. Tonalite, Coupall river, near Kingshouse, Glencoe, Argyllshire.

COMMUNICATIONS FROM THE OXFORD MINERALOGICAL LABORATORY. No. XVII.

On the structure and composition of the Chandakapur meteoric stone.

(*With Plates IX and X.*)

By H. L. BOWMAN, M.A., D.Sc.
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and H. E. CLARKE, B.A., B.Sc.
Jesus College, Oxford.

[Read November 17, 1908.]

Introduction. (H. L. B.)

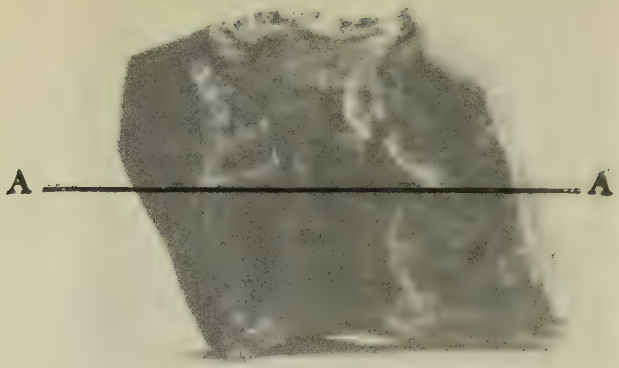
AMONG the chief treasures of the University Museum is a large piece of the meteoric stone which fell at or near Chandakapur in the valley of Berar, India, on June 6, 1838. The specimen has been for many years in the collection, but there seems to be no record of its acquisition or previous history. The weight was formerly 3329·5 grams,[1] but the stone was cut in two in 1899 and a portion exchanged with the late Mr. J. R. Gregory for a number of representative specimens of meteorites. A series of five thin sections were prepared at the same time, and about five grams of fragments remained, which have been used for the analysis described below. About 100 grams were lost in the cutting and preparation of sections, and 1385 grams were sent to Mr. Gregory. The weight of the piece now remaining at Oxford is 1839 grams.

With a specimen of the meteorite sent to H. J. Brooke by G. B. Sowerby in 1843, and now in the Cambridge Mineralogical Museum, is a letter from Sowerby enclosing a copy of one from Lady Elizabeth Harvey which quotes the following account of the fall, sent to her with two of the stones, therein called Nos. 1 and 2, by Colonel H. Smith, apparently about 1840.[2]

'At twelve o'clock at noon on the 6th of June, 1838, three meteorolites were discharged from the heavens with a loud explosion, the sky being cloudless and the atmosphere serene and calm at the time. They fell

[1] Owing to a clerical error this appears in Wülfing's Catalogue ('Die Meteoriten in Sammlungen,' 1896) as 6329 grams.

[2] Copies of this account, with slight differences in the weight of No. 3 (7 lb. 7 oz. according to the Edinburgh copy) and in the spelling of names, have been found with the specimens at Oxford and Edinburgh (see below, p. 351).



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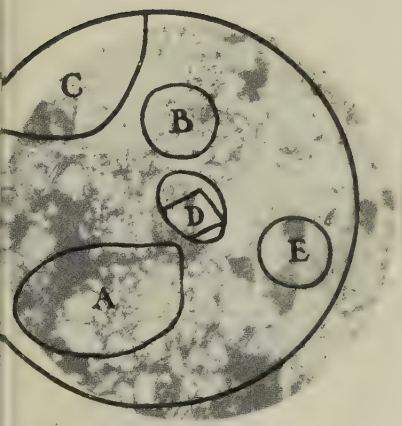

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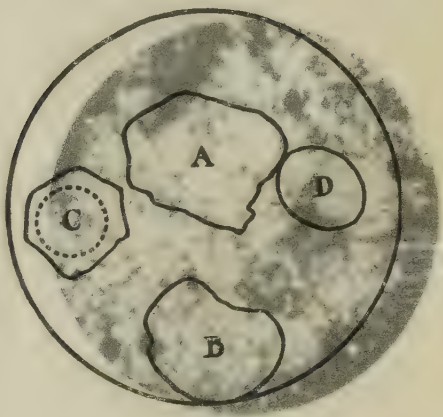

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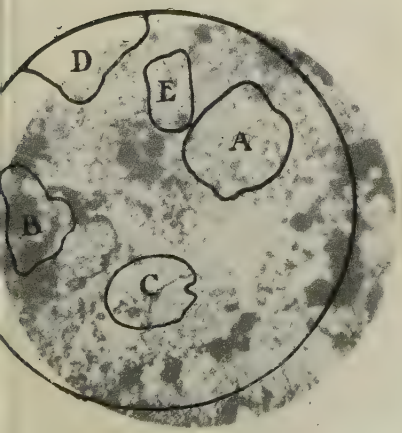

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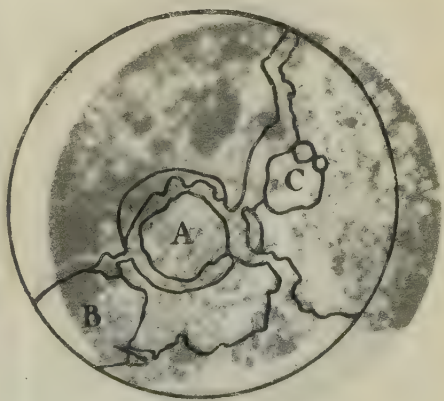

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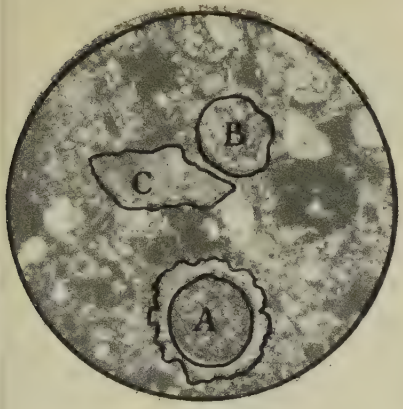

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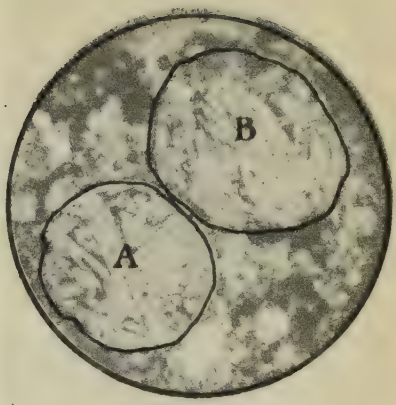

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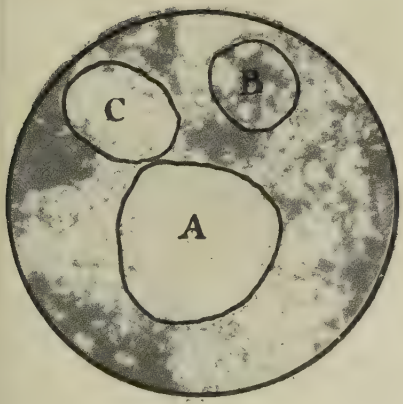

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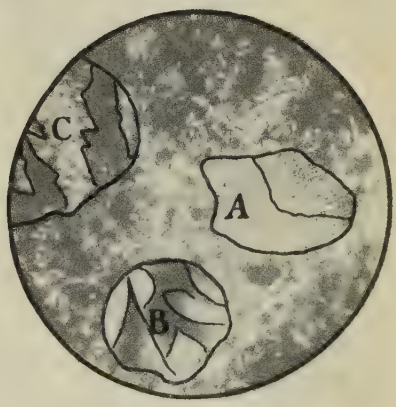

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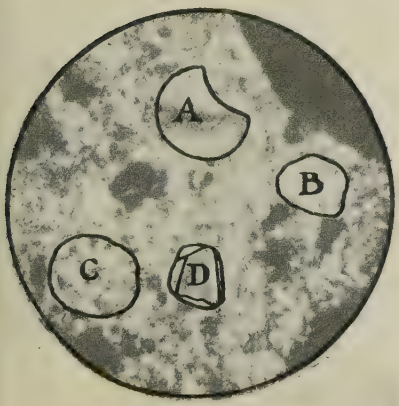

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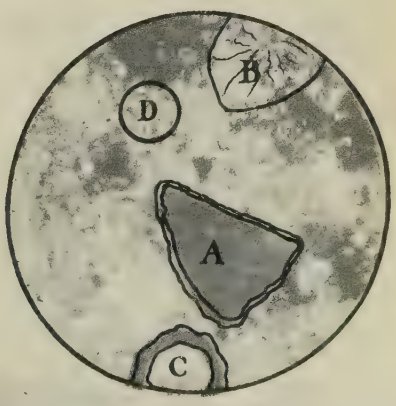

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simultaneously at the undermentioned villages[1] in the valley of Berar, situated Lat. 21° 45′, Long. 77° 20′ E.

[Grams.]

'At Chandakapoor, Pergunna Akoat, No. 1, weighing 11 lb. 3 oz.' [5074]

'At Burguon, Pergunna Burnaira Jemgge,
No. 2, weight 1 lb. 3½ oz.' [552][2]

'At Denulgaon Pergunna Puning Makagaon,
No. 3, weight 7 lb. 7½ oz.' [3342]

[8968][2]

'The third stone I saw but could not procure. It smelt strongly of sulphur. The villages were about a mile distant from each other, and the stones fell in a straight line.

'H. Smith, Brigadier
'Commanding at Ellidpoor'. [i.e. Ellichpoor]

If it may be assumed that this is a complete list of the stones known from this fall—and there appears to be no evidence to the contrary—it is possible to trace with some degree of certainty the subsequent history of the principal fragments.

The Royal Scottish Museum at Edinburgh contains a specimen labelled 'Chandakapoor' and weighing 2935 grams, and the label states that 'the original mass weighed 11 lb. 3 oz.' This specimen can therefore hardly be other than a portion of the stone No. 1, mentioned by Colonel Smith. It shows a surface covered with crust, a fractured surface, and a (probably more recent) wheel-cut surface.

In the same collection is also another stone, of 698 grams, labelled 'Burgaon 6th June, 1838, 1 lb. 8½ oz.', and accompanied by a copy of the letter from Colonel Smith quoted above. This, although the letter (as copied) speaks of 1 lb. 3½ oz., must clearly be No. 2. It is unbroken and entirely covered with crust, except at one or two points, where it has been chipped.[3]

It is unfortunately not now possible to ascertain how or when either

[1] The names of the villages are variously spelled in the other copies, as Akout, Akoat; Burgaon, Bargeon; Burnaira, Barnaire Jacqgu (?); Deursulgaon, Drunlgar. 'Ellidpoor' should doubtless be Ellichpoor (as in the Edinburgh copy).

[2] If, as seems probable, No. 2 is identical with the smaller of the two specimens at Edinburgh, its weight should be 698 grams, making the total weight of the fall about 9114 grams.

[3] The weight given in Professor Wülfing's table (loc. cit.) for the Edinburgh specimens appears to be traceable to some error in the weighing of the larger stone or in the conversion of its weight into grams.

of these specimens came into the Edinburgh Collection, but there is evidence that they were both there, together with another fragment of the same mass as No. 1, weighing $4\frac{1}{4}$ oz. (or about 120 grams), which cannot now be traced, in 1861; for they are mentioned in a list of meteorites made in that year by the Assistant Conservator of the Museum, Mr. J. B. Davies. The weight of the large piece of No. 1 is there given as 6 lb. $7\frac{3}{4}$ oz., or about 2941 grams.

The greater part of No. 1 having been traced to Edinburgh, the Oxford stone must be identical with No. 3, as would seem probable also from a comparison of the weights. All the fragments existing in other collections (amounting in 1893 to 1765 grams, according to Wülfing) must, consequently, have been portions of No. 1.

Since a piece of the stone (weighing 32·4 grams and now preserved at Cambridge) appears from the letter mentioned above to have been sent to Brooke by Sowerby in 1843, and since two fragments now in the British Museum, weighing 521 and 239 grams, were bought from Sowerby in 1843 and 1844 respectively, it follows that No. 1 must have been broken or cut soon after its arrival in England, and that at least a portion of it passed into Sowerby's possession from Lady Harvey, probably in 1843. Buchner[1] indeed states that Sowerby possessed a stone weighing 4200 grams, and this, if correct, would indicate that the large Edinburgh specimen must also have been obtained from him.

I have ascertained that fragments of the meteorite exist at the present time in the following collections:—

	Grams.
Budapest (42, 6, 0·8)	48·8
Calcutta (33·8, 19·8, 15·6, 0·7[2])	69·9
Cambridge (32·3, 1·9)	34·2
Edinburgh (Chandakapur 2935, Burgaon 698) ...	3633
London (B. M.) (521, 239, and three fragments) ...	764
„ (M. P. G.) (163·8, 3·5)	167·3
New Haven (41)	41
Oxford (1839)	1839
Tübingen (197, 8·9[3])	205·9
Vienna (1318, 98, 7)	1423
Ward-Coonley Collection (68, 23)	91
	8317·1

[1] O. Buchner, 'Die Meteoriten in Sammlungen,' Leipzig, 1863, p. 60.

[2] The small fragment has since been presented to the Oxford Museum, (1909).

[3] This fragment is said by Professor Wülfing to belong to the group Cia and not to be really Chandakapur. See, however, p. 354.

Of these, the larger of the two specimens in the Museum of Practical Geology in London and of those at Tübingen, are stated on the labels to be from a mass weighing 11 lb. 3 oz. The former was at one time in the collection of W. Nevill, and is mentioned in the catalogue of that collection, printed in 1877.

The portion of the Oxford stone cut off in 1899 passed into the hands of Mr. Julius Böhm, and a piece weighing 1318 grams is now in the Hof Museum at Vienna.

Since the Oxford specimen seems to have represented the whole of the mass which fell at Denulgaon (No. 3), the presence on it of a large fractured surface, showing no traces of fusion, points to its having originally formed part of a larger mass which split during its fall when at no great height from the ground. The Edinburgh portion of No. 1 also shows fractured surfaces but it is not possible to say if it is a part of the same mass.

Physical Characters of the Stone. (H. L. B.)

Form, Crust, and Macroscopic Characters.

Before being divided, the Oxford specimen had the form of a flattish block, of roughly rhombic outline, about $13 \times 12 \times 6$ cm. (see Plate IX, fig. 1).[1] Except on the large face at the back, which was a clean fracture, the whole stone was bounded by a natural external surface showing characteristic shallow pits and covered with a thin, dull, brownish crust. This latter is slightly rough, but shows no distinct lines of flow which might indicate the direction of flight of the stone.

The specimen was cut along a horizontal plane through AA, and the upper portion remains at Oxford.

On a recent fracture (probably dating from 1899), the stone appears compact, and of a grey colour with a few rusty specks and minute spangles of nickel-iron, and here and there a glittering crystal of olivine. On an older broken surface it is brownish-grey, with more numerous spots and general rusting. On the cut surface (1899) the colour and rusting are similar to those of the older fracture, and numerous chondrules (up to 6 mm. diameter, but usually much less) are visible. They are roundish, ovoid, or somewhat irregular, and mostly of a lighter colour (grey) than their surroundings. On the fractured surface the chondrules do not project or leave hollow casts, as in the group of

[1] A cast of the specimen is kept in the Museum.

'Kügelchenchondrite' of Tschermak, but break with the matrix, and are not very conspicuous on the rough surface.

The larger of the Edinburgh specimens shows three fairly flat, crusted surfaces, meeting in an obtuse corner, the longest edge being about 11 cm. in length. The back of the specimen is irregular, broken and somewhat splintered, except at one corner, where a piece (probably wedge-shaped) has been cut off, leaving a smooth surface of pear-shaped outline, about 14×9 cm. The fractured surface is greyish, with rusty spots, but without visible chondrules. On the smooth cut surface the iron grains are bright and the matrix of a darker mottled grey. The crust is thin, brownish and dull, slightly reticulated in some places, in others slightly rippled with streaming-marks.

The smaller specimen is of a somewhat flattened pear-shape, and is covered with a blackish crust. Its dimensions are about $11 \times 9 \times 5$ cm.

Of the two specimens in the British Museum, the smaller shows a flat polished surface, and is brownish-grey, with a streak of bluish-grey colour running through it. Numerous small chondrules are visible on the polished surface (especially on the bluer part), with grains of iron, one of which is embedded in a larger grain of brassy troilite. The larger specimen also shows some bluish patches and streaks in a grey mass. Its surface is partly covered by a slightly rough, brownish crust. Both the stones show traces of thin black veins on their fractured surfaces.

The Chandakapur stone is classed by Brezina[1] in the group of 'Breccia-like Intermediate Chondrites' (Cib) of Tschermak's classification.

The differently coloured patches in the specimens in the British Museum may perhaps point to the existence of a 'breccia-like' structure in the parent mass, so that these fragments might probably be classed as Cib, or from the presence of veins as Cia; but there is no indication of such a structure in the Oxford or Edinburgh specimens, and the Oxford stone at least (and probably the other also) should rather be classed with the 'Intermediate Chondrites' (Ci).

Assuming that the specimens in the British Museum are correctly named, there appears to be considerable variation in the structure of different stones from this fall, and even in different fragments of the same stone (No. 1).

The specific gravity was given by Greg[2] as 3·53: it has not been re-determined.

[1] A. Brezina, 'Die Meteoritensammlung des k.k. Hofmuseums am 1. Mai 1895.' (Ann. des k.k. Naturhist. Hofmuseums, 1896, vol. x, p. 248.)

[2] R. P. Greg, Phil. Mag., 1854, ser. 4, vol. viii, p. 460.

Microscopic Characters.

An examination of the sections under the microscope shows that by far the most important constituents are olivine and minerals of the pyroxene group. There are also present specks of nickel-iron, some other opaque materials (including rust and possibly some glass), and a few minute grains, probably representing felspar. Well-formed chondrules are numerous and show a remarkable variety of form and structure. They are mostly round or ovoid, usually with a diameter of 0·8 to 1·2 mm., while some few are irregular and probably fragmentary. Some are sharply bounded by an opaque border of iron, more or less rusted, while others shade off into the surrounding matrix. They mostly contain olivine or pyroxene in various forms, or a mixture of both, often with some included glass. The matrix is granular, of varying coarseness, and consists of irregular fragments of the same materials as the chondrules, usually of smaller size, though large fragments also occur. In some places it is hard to say whether a certain area represents chondrule or matrix. Except where the section is stained with iron, there is a prevailing absence of colour, all the transparent minerals being colourless, while only the matrix of some of the porphyritic chondrules and a few semi-opaque radial-fibrous chondrules are grey or brownish.

The Constituent Minerals.

The olivine occurs in grains and well-formed crystals, as well as forming monosomatic chondrules, and shows uniform extinction and the usual bright interference-colours.

Of the minerals identified as pyroxene there appear to be several varieties present. They are all colourless and show high relief, but they differ in their birefringent properties. The following may be distinguished:—

(α) Oblong crystals and grains, somewhat fibrous, with a longitudinal cleavage and traces of transverse cracks, showing uniform straight extinction and low interference-colours (grey or sometimes yellow), and compensated by a quartz-wedge[1] inserted transversely. These are typical rhombic pyroxene.

(β) Similar crystals and grains, showing imperfect, patchy extinction (approximately straight) and compensation as above.

(γ) Similar crystals and grains, showing a more or less regular lamellated structure and resembling a plagioclase-felspar, but for the

[1] i. e. one cut with its length parallel to the principal axis of the crystal.

high relief. One crystal, which appears to be cut nearly at right angles to the plane of the lamellae, gives on two adjacent lamellae extinction-angles of $31\frac{1}{2}^\circ$ and $34\frac{1}{2}^\circ$ on either side of the junction.

From their general similarity in appearance and the existence of intermediate forms, it may be inferred that these all represent varieties of the same mineral. The apparently uniform crystals (*a*) would then be really compound, but with a finer twin-lamellation than the others. This material probably constitutes the bulk of the silicate unattacked by hydrochloric acid, and according to the analysis (p. 372) will have the composition of a bronzite [1] poor in iron.

In this connexion we may recall the observation, by Fouqué and Michel Lévy, of the occurrence of a monoclinic magnesium-pyroxene with twin-lamellation resembling that of a plagioclase, in the meteorites of Rittersgrün and Sarbanovac,[2] and in the products of the experiments of Ebelmen [3] and Meunier [4] on the artificial reproduction of meteorites.

If the above explanation is correct, the material affords a confirmation of the view held by Groth as to the pseudosymmetric character of the 'rhombic pyroxenes'.

There are also a few fibrous fragments and grains showing higher interference-colours and a large extinction-angle, which may probably represent a monoclinic pyroxene of the ordinary type (e. g. C in fig. 5).

Here and there in the ground-mass, lying among and sometimes enclosing grains of bronzite, may be seen small, colourless particles with weak birefringence and no visible relief. They show traces of a biaxial interference-figure, and are probably felspar, though there is no indication of twinning or of cleavage.

The Chondrules.

Some of the principal types of chondrules are shown in Plates IX and X, figs. 2–11.

The commonest are polysomatic olivine chondrules with either granular or porphyritic structure, the latter often showing very well-formed crystals embedded in a compact, brownish glass. The crystals are usually rhombic or six-sided in outline, and then lie irregularly in the chondrule (figs. 2 and 3), but they are not uncommonly elongated and

[1] i. e. if this term be used for rhombic pyroxenes with 5 to 15 per cent. of FeO (cf. E. Cohen, 'Meteoritenkunde,' 1894, Part i, p. 282).

[2] F. Fouqué and A. Michel Lévy, Bull. Soc. Min. de France, 1881, vol. iv, p. 280; see also E. Cohen, loc. cit., p. 300.

[3] Ebelmen, Ann. Chim. Phys., 1851, ser. 3, vol. xxxiii, p. 58.

[4] S. Meunier, Compt. Rend. Acad. Sci. Paris, 1880, vol. xc, p. 349.

tend to lie in parallel positions (fig. 4), thus showing a transition to the monosomatic chondrules enclosing parallel layers of glass (somewhat similar to those which have been described by Tschermak [1]) which occasionally occur here (fig. 5, cf. also fig. 6).

Almost equally common are chondrules consisting of large prismatic crystals of pyroxene of types a, β, γ, either alone (as A, in fig. 7), or with some crystals or grains of olivine (as B, in fig. 7).

Round chondrules, with eccentric-fibrous structure, are not uncommon (figs. 9 and 10). The fibres show straight extinction and transverse compensation, with low colours, and are probably bronzite. The fibres may radiate from one or from several centres. One such chondrule shows a circular outline with a smooth concavity on one side (fig. 10). The regular arrangement of the fibres, which radiate from a point slightly outside the limits of the chondrule, is in no way disturbed by the latter. The chondrule was probably formed in contact with another somewhat larger one, of which, however, no trace remains. A small indentation of the same kind may be seen in B, fig. 9.

Certain bronzite chondrules, usually of roughly oval or irregular form, show a peculiar grating-like structure (A, in fig. 9), due to the inclusion of layers of glass in a large crystal in definite directions. The chondrule shown in the figure appears at first to be monosomatic, but compensation with the quartz-wedge shows that it consists of two crystals with parallel extinction, but with their principal vibration-directions crossed, each portion being compensated on insertion of the wedge at right angles to the layers of glass. The latter appear to be parallel to a (100), while the section is roughly parallel to c (001).

Several examples of monosomatic olivine chondrules are present, of the remarkable type, with a circular nucleus containing regularly arranged glass inclusions, observed by Tschermak [2] in the meteorites of Tieschitz, Mezö-Madaras, and Alfianello. The most striking of these is shown in fig. 6. The border is optically continuous with the nucleus, the whole showing practically uniform extinction, and cleavage-cracks may be traced from the border into the nucleus. The latter consists of a more or less regular intergrowth of olivine with granular, brownish, isotropic glass, resembling graphic granite; while the border is free from glass but contains numerous irregular grains of nickel-iron and other opaque materials (rust?). The chondrule shows no definite outline, but spreads

[1] G. Tschermak, 'Die mikroskopische Beschaffenheit der Meteoriten,' (Stuttgart, 1883–1885), Plate viii, fig. 4; x, 2; xi, 2.

[2] G. Tschermak, loc. cit.

out irregularly into the surrounding matrix in a way which strongly suggests that it has grown *in situ*, possibly before the solidification of the matrix.

Another bordered chondrule, with more regular platy inclusions in its nucleus, is shown in fig. 5. Here, however, a portion of the border is granular and the outline is sharply defined by a thin shell of rust (?).

A few chondrules, such as C in fig. 9, consist of lamellae showing alternately colours of high and low order, which appear to represent an intergrowth of two pyroxenes.

An angular fragment of compact fibrous material (probably bronzite), is grey and semi-opaque with fine dusty inclusions, but has a pale yellowish border, free from inclusions, completely surrounding it (A, fig. 11).

One granular olivine chondrule, seen at the edge of fig. 11, is surrounded by a triple border consisting of three concentric layers of black, opaque inclusions lying in a finely granular material.

Chemical Analysis. (H. E. C.)

I. *Experimental Work.*

Principles of the Method Employed.

§ 1. For the determination of the proportions and composition of the nickel-iron and various constituent minerals present in the meteorite, the methods adopted by Mr. L. Fletcher[1] in the analysis of the Zomba and Makariwa meteoric stones have been applied in the present work. Briefly these are—

(i) A preliminary separation of the magnetic material from the dry powder by means of a magnet, and the extraction of the metallic constituents from the two portions so obtained, by the prolonged action of a solution containing mercuric chloride, in an atmosphere freed from oxygen (§§ 3–5).

(ii) The reduction of rust, magnetite, sulphides, and phosphides to the metallic state by ignition in hydrogen, and extraction of the resulting metals with mercuric solution (§ 15).

(iii) The separation of the silicates into two portions, by treatment with hydrochloric acid under conditions favourable to the attack of olivine but not of pyroxene or felspar (§ 18).

[1] L. Fletcher, Mineralogical Magazine, 1901, vol. xiii, p. 1 ; 1894, vol. x, p. 287.

(iv) The analysis of the resulting fractions (§§ 6–14, 16–17, 19–20) and the estimation of alkalis and of sulphur and phosphorus (§§ 22, 24) by the usual analytical methods.

The Material.

§ 2. The material used for the analysis consisted of seven small fragments, weighing together rather less than 5 grams, which were obtained during the slicing of the Oxford specimen in 1899. Four showed fused crust on some part of their surface, and all were superficially rusted. The largest fragment weighed, after removal of crust, 1·3375 grams. This and two other portions were scraped clean, and weighed 2·0210 grams before crushing.

Magnetic Separation.

§ 3. The fragments were first crushed in a covered agate mortar, and the stony portion finely powdered, after removal of the nickel-iron and other magnetic minerals with a magnetized knife-blade, care being taken to avoid loss of powder and splinters during the operations. The portion attracted by the magnet weighed 0·2843 gram, the portion unattracted 1·7341 grams[1], making 2·0184 grams in all (sample A). The amount lost during powdering and magnetic separation was, therefore, 0·0026 gram.

The 'attracted' portion, representing for the most part nickel-iron, schreibersite, and perhaps troilite,[2] was by no means free from silicates, while it was anticipated that the material left after the magnetic separation would still contain finely divided magnetic minerals entangled among the non-magnetic particles. In order to determine the amount of nickel-iron present, and also to effect as complete a separation as possible of the metallic from the non-metallic constituents of the stone, it was therefore necessary to treat both the attracted and the unattracted portions with mercuric solution.

[1] Referred to as 'the attracted portion' and 'the unattracted portion', respectively.

[2] Some authors have stated that two varieties of iron sulphide occur in meteorites, of which one is magnetic and regarded as identical with terrestrial pyrrhotite (Fe_nS_{n+1}), while the other is non-magnetic, or only feebly magnetic, and has been assumed to consist of monosulphide (FeS). In the present paper, the name troilite is used for iron sulphide in general, without regard to its magnetic or non-magnetic character.

Dissolution of Free Metals by means of a Mercuric Solution.

The Mercuric Solution.

§ 4. Iron, nickel, cobalt, and copper all dissolve readily in solutions of mercuric chloride, metallic mercury being precipitated, and, in the case of iron, mercurous chloride also, owing to the partial oxidation of ferrous to ferric chloride at the expense of the mercuric salt. If the operation be carried out in air a scum of yellow basic iron chloride rapidly forms, and in order to keep all the iron in solution it is convenient to allow the action to proceed in an atmosphere of hydrogen.

Mercuric chloride, however, except in dilute solution, has an appreciable action upon troilite. Indeed the latter may be completely dissolved by prolonged heating on the water-bath with an aqueous solution of mercuric chloride. The same reagent also attacks olivinic silicates to some extent, the action being doubtless in both cases attributable to acid formed by hydrolysis of the salt. The acidity may be reduced by the introduction of chlorine ions, as, for example, by the addition of a neutral soluble chloride, such as ammonium chloride. Thus cold solutions of the double salt $HgCl_2 \cdot 2NH_4Cl \cdot 2H_2O$ react neutral and do not attack silicates, troilite, or schreibersite. Friedheim,[1] Fletcher,[2] Tassin,[3] and others, have used this salt with success, 12 grams being dissolved in one litre; and this concentration has been adopted for the present work. In practice, 7·8 grams of mercuric chloride were dissolved with 3·1 grams of ammonium chloride in air-free water, and the solution made up to one litre.

The Extraction.

§ 5. The 'attracted' and 'unattracted' portions were transferred to separate Jena glass flasks and known volumes of the reagent added. The air in the flasks was then displaced by a current of hydrogen, and the gas passed at a convenient rate through the solutions, which were frequently shaken. After a time the precipitates were allowed to settle, the solutions decanted off through filters, and fresh mercuric solution added as before. The filter-papers were rapidly washed with a stream of diluted mercuric solution, and each filtrate at once acidified with hydrochloric acid. As it was proposed to investigate the process of solution of the nickel-iron alloys, the several extracts were analysed separately.

[1] C. Friedheim, Sitzungsber. Akad. Wiss. Berlin, 1888, p. 345.

[2] L. Fletcher, loc. cit. (vol. x, pp. 288, 293).

[3] W. Tassin and G. P. Merrill, Proc. United States National Museum, 1907, vol. xxxii, p. 241.

The results showed that both 'unattracted' and 'attracted' portions were at first materially attacked. The former, however, gave a negligibly small yield of iron after five extractions, occupying one week in all and requiring 450 c.c. of the reagent; while the 'attracted' material required eight extractions, extending over about seven weeks, 550 c.c. of the mercuric solution being used.

Analysis of the Extracts.

Method of Precipitation.

§ 6. The acidified extracts were separately treated with hydrogen sulphide, and the resulting black precipitates examined for non-volatile material by gentle ignition. In all cases a minute residue remained, but it was soon apparent that the mass of this bore no relation either to the volume of the reagent used or to the length of time allowed for an extraction.

§ 7. The filtrates were severally reduced in bulk by evaporation on the water-bath, and oxidized by addition of a little nitric acid. For the separation of iron from nickel and traces of cobalt, the method of repeated precipitation with ammonia in presence of ammonium chloride has been used, as recommended by von Baumhauer.[1]

The oxidized filtrates were heated to boiling and about 0·5 gram of solid ammonium chloride added; then ammonia until the liquid was distinctly alkaline. The mixture was boiled for ten minutes and allowed to stand overnight. The supernatant liquid was then decanted off, the precipitate washed with hot water, dissolved in hydrochloric acid, and after addition of a little ammonium chloride re-precipitated with ammonia. The process was repeated for the third time, as before, the mixture being boiled for a considerable time, with addition of ammonium chloride, before filtering. The precipitate on the paper was then washed until free from chloride. This procedure is believed to afford a satisfactory separation of iron from nickel,[2] and was followed in every precipitation of ferric hydroxide.

§ 8. The filtrates were evaporated down and cooled, and after addition of ammonia were saturated with hydrogen sulphide. The liquids were

[1] E. H. von Baumhauer, Arch. Néerland. Sci., 1871, vol. vi, p. 46.

[2] A test-experiment was made with approximately equal weights of ferrous-ammonium and nickel-ammonium sulphates; after a threefold precipitation of the iron with ammonia as above, the solution showed no trace of iron on being tested with potassium thiocyanate, while the precipitate contained no determinable amount of nickel hydroxide.

then allowed to stand[1] in the cold until the sulphides settled in filterable form; the precipitates were filtered off, and the filtrates neutralized with acetic acid and treated with hydrogen sulphide in order to remove traces of nickel dissolved by the ammonium sulphide. In general, two precipitations are necessary and sufficient, as may be shown by the failure of the Pozzi-Escot molybdate test for nickel[2] at that stage in a test-experiment with nickel-ammonium sulphate.

The precipitates were dissolved and the nickel and cobalt reprecipitated with potassium hypobromite and weighed as (NiO + CoO). The sulphide-precipitate was found to be free from manganese and zinc.

§ 9. In order to determine whether the mercuric solution had attacked the silicate to a measurable extent, the solutions, when freed from nickel and cobalt, were tested in the usual manner for calcium and magnesium. The lime obtained from all the extracts amounted only to 0·0010 gram, the magnesia to 0·0008 gram. An independent analysis of the solution obtained by boiling the 'unattracted' portion with water in a platinum dish, further proved the very small solubility of the calcium and magnesium minerals in water.[3]

Estimation of Iron, etc., in the Extracts.

§ 10. The sesquioxide-precipitates from all the extracts weighed 0·1512 gram, the nickel and cobalt oxides 0·0288 gram. The former were brought into soluble form by fusion with potassium bisulphate, and the iron determined, after reduction to the ferrous state, by titration with acid permanganate in the usual manner. The results indicated 0·1053 gram of metallic iron, corresponding to 0·1504 Fe_2O_3. It follows that the extracts with mercuric solution were free from chromium and aluminium.

Thus the composition of the metallic portion of the stone, expressed in percentages of the total material, is:—

Fe	... ...	5·25 per cent.
(Ni,Co)	... ...	0·55 „
Cu	... ...	trace.

[1] The precipitation of nickel sulphide by means of colourless ammonium sulphide is a time-reaction, which is apparently accelerated by light. Possibly the rate of precipitation may depend upon the rate of formation of ammonium polysulphides.

[2] M. E. Pozzi-Escot, Compt. Rend. Acad. Sci. Paris, 1907, vol. cxlv, p. 435.

[3] 0·1667 gram of the powder was treated with 50 c.c. distilled water and evaporated to dryness on the water-bath. After repeating the process four times,

Results of the analysis of the successive extracts.

§ 11. The several non-volatile residues, left after removal of the mercury (§ 6), weighed altogether 0·0087 gram, of which 0·0038 gram came from the extracts of the 'attracted', and 0·0049 gram from those of the 'unattracted' portion.

The residues gave with hydrochloric acid a yellow solution consisting of ferric chloride with some slight traces of copper chloride. In estimating the iron obtained in solution at each extraction, that carried down in this way with the mercuric sulphide has therefore been included.

§ 12. The following tables show the amounts of iron and nickel removed by successive extractions. In the last column is given the ratio Ni : (Fe + Ni).

No. of extraction.	Period.	Mercuric solution used c.c.	Fe grams.	Ni grams.	Ni : (Fe + Ni) per cent.
		'Attracted' Portion.			
1.	3·5 hours	100	0·0563	0·0072	11·3
2.	16 „	50	0·0259	0·0041	13·6
3.	15 „	100	0·0082	0·0020	20·0
6.	7 days	50	0·0030	0·0013	30·2
7.	20 „	100	0·0015	0·0008	34·8
		'Unattracted' Portion.			
1.	3·5 hours	150	0·0049	0·0026	34·6
2.	16 „	100	0·0013	0·0007	35·0
3.	30 „	50	0·0012	0·0008	40·0
4.	96 „	100	0·0022	0·0017	43·6

In the 4th, 5th, and 8th extracts of the 'attracted,' and the 5th of the 'unattracted' portion, the amount of NiO never exceeded 0·0005 gram.

§ 13. The fact observed by Mr. Fletcher in the case of Zomba and Makariwa, that the proportion of nickel to iron increases as the extraction proceeds, is borne out by these results with Chandakapur; and it is further interesting to note that the proportion of Ni : (Fe + Ni) in the last extract of the attracted portion is 34·8 per cent., or almost as

the solution gave, on analysis in Jena glass vessels, 0·0008 gram CaO and 0·0017 gram $Mg_2P_2O_7$.

Mr. Fletcher found the soluble material of the Zomba stone to consist principally of calcium sulphate. It is interesting therefore to note that Chandakapur contains practically no soluble calcium salt, and that the aqueous extract contains no sulphate. The dissolved material consists for the most part of sodium carbonate.

high as that in the alloy common to Zomba and Youndegin,[1] which contains about 38·5 per cent. of nickel. The 'unattracted' material furnishes a still higher percentage of nickel, the first extract representing an alloy as rich in this metal as the last of the 'attracted' extracts. The alloy represented by the fourth extract of the 'unattracted' portion of Chandakapur would contain 43·6 per cent. of nickel, the highest value yet observed in a meteoric stone.[2]

§ 14. These results are perhaps not so surprising when the following points are considered:—

(i) The alloys of iron and nickel become more brittle and less malleable as the proportion of nickel increases. An alloy rich in nickel is thus more likely to be reduced to a fine state of division during crushing than one richer in iron, and it is the smaller magnetic particles which escape separation during treatment with the magnet.

(ii) The alloys rich in nickel are less magnetic than those richer in iron. This is a further reason for the appearance of the nickel-rich metal in the 'unattracted' portion.

(iii) The rate of solution of nickel-iron alloys in solvents of both metals is greater for alloys poor in nickel than for those rich in nickel.

Some experiments have shown that when iron and nickel form a galvanic couple in mercuric-ammonium chloride, only the iron passes into solution, the nickel receiving a protective layer of mercury and mercurous chloride. If compounds of iron and nickel, and mixed crystals of these elements, also dissolve the more readily in mercuric solution the higher their content of iron, the proportion of nickel in the metallic material still unattacked, and hence in the material passing into solution, should be found to increase as the extractions proceed.

(iv) Supposing oxidation to occur during extraction and filtration, the iron will be affected by it more than the nickel. The material thus left in the metallic state will be richer in nickel than before, and this will be shown by an ever increasing proportion of nickel, as compared with iron, in the extracts. The fact that Chandakapur is a rusted stone renders it difficult to decide to what extent the iron may have become oxidized during the analytical operations. This, however, could readily be determined in the case of a meteorite free from rust when mercuric extraction was commenced.[3]

[1] L. Fletcher, Mineralogical Magazine, 1908, vol. xv, p. 147.

[2] The anomalous taenite, isolated by acid from the Beaconsfield iron, alone shows a higher proportion, viz. 48·6 per cent. (see O. Sjöström, Sitzungsber. Akad. Wiss. Berlin, 1897, p. 1041).

[3] Cf. L. Fletcher, Mineralogical Magazine, 1908, vol. xv, p. 147.

Treatment of the Residues unattacked by Mercuric Solution.

Reduction of rust, magnetite, schreibersite, and troilite, and extraction of the reduced metals.

§ 15. The metallic material having now been extracted as completely as possible from both the 'attracted' and the 'unattracted' portions, the residues containing the non-metallic constituents were filtered off and washed, the runnings being added to the last extracts. The dried residues were mixed and worked over with the magnet, in order to separate the non-metallic magnetic minerals (magnetite, schreibersite, and perhaps troilite [1]) from the non-magnetic rust and silicates. Each part was then transferred to a porcelain boat and heated to bright redness in a stream of hydrogen. Mercury and mercurous chloride were thus removed, and all constituents except the silicates and chromite reduced to the metallic state. After forty-eight hours no further evolution of hydrogen sulphide (from the decomposition of troilite) could be observed, and the products were allowed to cool in hydrogen. The reduction-product (N) of the non-magnetic material was of a greyish-black colour, that (M) of the magnetic material quite black. Both N and M were treated with mercuric solution in a stream of hydrogen. While both gave up considerable amounts of iron to the solvent (M yielding 0·0966 gram, and N 0·0170 gram, of Fe_2O_3), only M contained any weighable quantity of nickel (0·0086 gram (Ni,Co)O), traces only being found in N. It may be inferred therefore, that if the material has undergone oxidation during the extractions of § 5, the iron only has been measurably affected.

The mercuric extracts of M and N further yielded the following amounts of silica and bases [2]—

SiO_2	...	...	...	...	0·0022 gram.
CaO	...	...	...	...	0·0053 „
MgO	...	...	...	...	0·0017 „

Analysis of the silicate-residues remaining after extraction.

§ 16. The residues left after removal of free iron and nickel from M and N were of a light grey colour, becoming brown on ignition, and then weighed, together, 1·7752 grams. After fusion with sodium and

[1] See foot-note to § 3.

[2] Due to some action on the silicates during reduction. Cf. L. Fletcher, Mineralogical Magazine, 1901, vol. xiii, p. 17.

potassium carbonates in the usual way,[1] a few dark, gritty particles (chromite ?) remained on extraction of the melt, and as these did not yield to a further fusion for thirty minutes with sodium carbonate, they were removed with the silica and weighed after volatilization of the latter with hydrofluoric acid.

§ 17. The following results were obtained from the analysis of the material submitted to fusion :—

	Grams.	
SiO_2...	0·7674	including the silica from the mercuric extracts.
Fe_2O_3	0·4442	
Al_2O_3	0·0841	
Cr_2O_3	0·0022	
NiO (including CoO)	0·0015	
CaO	0·0495	including the lime and magnesia from the mercuric extracts.
MgO	0·4313	
Unattacked chromite	0·0068	
CuO	traces.	

The percentage results are collected in the table on p. 371.

Determination of the composition of the Silicates present.

Separation of the Silicates by treatment with hydrochloric acid.

§ 18. In order to determine, if possible, the actual silicates present in the meteorite, and to find their approximate composition, the method of separation by hydrochloric acid, under conditions favourable to the attack of olivine without appreciable gelatinization of pyroxenes and felspars, was employed.[2]

For this purpose a mixture of 1·06 specific gravity (made by diluting three parts of concentrated hydrochloric acid of sp. gr. 1·16, with five parts of water) was used, as recommended by Mr. Fletcher. As no more of

[1] Only a portion of the material should have been used for this purpose, but by an oversight the whole was mixed with the carbonates. Fresh samples of the stone consequently had to be used for the estimations described in §§ 18–20, 22, 24. The comparison given in § 21 shows, however, that the main sample resembles the smaller one of § 18 closely in composition, so that a comparison of the results obtained from the various portions is probably justifiable.

[2] L. Fletcher, Mineralogical Magazine, 1894, vol. x, p. 288.

the portion of material originally extracted with mercuric solution was available, another fragment of the stone (B), which weighed, after grinding, 0·5326 gram, was treated with about 100 c.c. of the acid in a platinum basin on the water-bath. At the end of half an hour the yellow extract was decanted off through a filter and a fresh extraction carried out for a further 30 minutes. A third extraction of a similar kind was continued for one hour: the third extract was practically colourless. The residue, consisting of unattacked silicates and gelatinous silica, with a little chromite, was well washed by decantation (the washings being also passed through the filter) and then heated on the water-bath with a strong solution of sodium carbonate until there was no gelatinous silica visible, when the alkaline solution was poured off through the same filter (now holding a little silica from the washings). The residue was again treated with hot sodium carbonate solution and finally washed with boiling water.

In order to determine the mass of the undissolved silicate on the filter-paper, it was dried, transferred to a platinum crucible and weighed (= 0·1488 gram). It was then ignited at a bright red-heat and reweighed (= 0·1469 gram). The paper (ash = 0·0002 gram) with its traces of adhering silicate was now burnt into the crucible, ignited, and the whole again weighed (= 0·1866 gram). The residue on the paper was thus determined as $\frac{0\cdot1488}{0\cdot1469} \times 0\cdot0395$, or 0·0401 gram. Thus the material unattacked by hydrochloric acid will weigh altogether 0·1889 gram; that attacked by acid 0·3437 gram.

Analysis of the separated Silicates.

§ 19. The 'bases' of the attacked silicates were obtained in solution as chlorides in the acid extracts. These further contained chlorides of iron and nickel from the free metal, sulphides, phosphides, and oxides present in the stone. After removing the silica from this solution in the ordinary manner, the sesquioxides were separated by a threefold precipitation with ammonia (§ 7), the nickel by means of ammonium sulphide, the calcium by double precipitation with ammonium oxalate, and the magnesium with ammonium phosphate.

The alkaline extract was acidified with hydrochloric acid, and the main portion of the silica of the attacked silicate obtained from this by evaporation in the usual manner.

The following were the results obtained:—

Silicate attacked by Acid.

SiO_2	0·1027 gram.
MgO	0·0765 „
FeO[1]	0·0931 „
CaO	0·0046 „
Al_2O_3	0·0112 „
Cr_2O_3	nil
K_2O, Na_2O	not determined.

The percentage composition is given in the table on p. 372.

§ 20. The unattacked silicate was dried and fused with sodium carbonate, and the melt analysed according to the ordinary methods of rock analysis.[2] The following results were obtained:—

Silicate unattacked by Acid (with Chromite).

SiO_2	0·1018 gram.
MgO	0·0379 „
FeO	0·0150 „
CaO	0·0146 „
Al_2O_3	0·0132 „
Cr_2O_3	0·0003 „
Chromite	0·0032 „
CuO	trace
K_2O, Na_2O	not determined

The percentage composition is given in the table on p. 372.

Comparison of results obtained from different portions of material.

§ 21. When a comparison is made between the results obtained from the portion of the stone (A) used for the bulk analysis (2·0184 grams, see § 3) and from that (B) divided into two parts according to the behaviour with hydrochloric acid (0·5326 gram, see § 18), the following percentage values are obtained for silica and for the four principal bases combined with it:—

[1] In order to obtain the amount of FeO present in the silicate, an amount of Fe_2O_3 corresponding to the amounts of nickel-iron, phosphide, sulphide, and oxide, present in the stone (see § 22) has been subtracted from the total Fe_2O_3 precipitated, and the remainder considered as representing FeO.

[2] W. F. Hillebrand, 'The Analysis of Silicate and Carbonate Rocks.' United States Geol. Survey Bull. No. 305, 1907, pp. 1–200.

	A (2·0184 grams.)	B (0·5326 gram.)
SiO_2	38·02	38·39
MgO	21·31	21·48
CaO	2·42	3·60
FeO	19·81	20·29 [1]
Al_2O_3	4·17	4·58

It thus appears probable that fragments of the Chandakapur stone show a fairly constant average composition in samples of half a gram. The collecting together of results obtained from several different samples could not be justified except on these grounds.

Estimation of Sulphur and Phosphorus.

§ 22. During the reduction in hydrogen described in § 15 a considerable amount of hydrogen sulphide was formed. This gas was also evolved when the stone was treated with dilute acid. A fresh portion (C) of the stone, which weighed, after grinding, 0·5774 gram, was treated with aqua regia, and from the solution of sulphates and phosphates so produced, the sulphur was removed as barium sulphate and the phosphorus as magnesium-ammonium phosphate, according to the methods described by Mr. Fletcher.[2]

The weights obtained were—

BaSO 0·0752 gram, corresponding to 1·79 per cent. Sulphur.

$Mg_2P_2O_7$ 0·0033 gram, corresponding to 0·16 per cent. Phosphorus.

From these values it follows that 3·13 per cent. of iron is combined with sulphur as troilite (FeS), and 0·60 per cent. with phosphorus and nickel as schreibersite (Fe_2NiP). When this iron is weighed as Fe_2O_3, as was done in treating the reduced material of § 15 and in the analysis of the portion of the stone attacked by hydrochloric acid (§ 19), the sulphide accounts for 0·0902 gram and the phosphide for 0·0171 gram of Fe_2O_3 in 2·0184 grams of the stone.

Estimation of Rust and Magnetite.

§ 23. The reduced product (M) of the non-metallic magnetic minerals, was found to yield only 0·0966 gram Fe_2O_3 (§ 15), though from the values given in the last section it appears that the troilite and schreibersite together should yield 0·1073 gram Fe_2O_3, and this quantity would be

[1] See foot-note to § 19.

[2] L. Fletcher, Mineralogical Magazine, 1894, vol. x, p. 298.

further increased if, besides troilite and schreibersite, magnetite was also present in the material attracted by the magnet (§ 15). It is therefore possible that the unattracted material still retained a portion of the feebly magnetic or non-magnetic[1] troilite, whose reduction would then account for part of the Fe_2O_3 obtained from N.

If this view be accepted, we obtain, by subtracting 0·1073 gram from the total ferric oxide (= 0·0966 + 0·0170 gram) yielded by M and N, 0·0063 gram, as a measure, in terms of Fe_2O_3, of the rust and magnetite in 2·0184 grams of the stone. In the absence of further data as to the composition and amount of the rust, we shall probably not be much in error if we take it and the magnetite together, calculating them as Fe_3O_4.[2] They then constitute 0·30 per cent. of the meteorite.

Estimation of the Alkalis.

§ 24. A test (see § 9, foot-note) made to determine to what extent the stone is soluble in water, showed that an alkaline substance containing sodium could be obtained by evaporating an aqueous extract to dryness.

(i) An experiment was made with a portion (D) of the stone reduced to fine powder and weighing 0·5367 gram. This was treated with water for three hours in a platinum dish on the water-bath, the water being replenished as required. After filtration of the solution and evaporation to dryness, a white residue remained which effervesced slightly with hydrochloric acid. The chloride so formed weighed 0·0043 gram, and represented 0·0005 gram K_2O, with 0·0019 gram Na_2O.

(ii) The insoluble residue was treated with hydrochloric acid in the manner described in § 18, except that the unattacked silicate was filtered off without treatment with sodium carbonate. The acid extract was evaporated to dryness, the residue gently ignited, and dissolved in water. The bases other than soda and potash were then removed by the method adopted after a Lawrence Smith fusion. The mixed chlorides eventually obtained weighed 0·0081 gram and yielded 0·0015 gram K_2PtCl_6.

(iii) The residue unattacked by acid was left mixed with gelatinous silica on the filter-paper. It was dried, and after transferring to a platinum crucible with the ash of the filter-paper was heated with pure calcium carbonate and ammonium chloride according to the method of Lawrence Smith.

After complete removal of calcium, 0·0039 gram of mixed alkali chlorides was obtained. Chloroplatinic acid precipitated 0·0043 gram K_2PtCl_6.

[1] See foot-note to § 3.

[2] Cf. L. Fletcher, Mineralogical Magazine, 1894, vol. x, p. 313.

From these values it follows that the alkalis of—

(i) are equivalent to 0·0005 gram K_2O and 0·0019 gram Na_2O.

(ii) are equivalent to 0·0003 gram K_2O and 0·0039 gram Na_2O.

(iii) are equivalent to 0·0008 gram K_2O and 0·0015 gram Na_2O.

The meteorite thus contains[1] 0·29 per cent. K_2O and 1·26 per cent. Na_2O, the greater part being contained in the material dissolved by dilute hydrochloric acid, of which 0·23 per cent. is K_2O and 1·67 per cent. Na_2O. A portion comparatively richer in potash is contained in the silicates unattacked by acid, of which K_2O forms 0·42 per cent. and Na_2O 0·78 per cent.

II. General Results of the Analysis.

Chemical Composition.

§ 25. From the values obtained above, the following results may be collected, expressing the composition of (1) the meteorite in bulk, (2) the metallic portion, (3) the silicates attacked by acid, (4) the silicates unattacked by acid :—

1. *Composition of the meteorite in bulk.*

In metallic state.	Iron	5·25
	Nickel (and cobalt)	0·55
	Copper	trace
Combined.	Iron (as troilite and schreibersite) ...	3·73
	Nickel and cobalt (as schreibersite) ...	0·31
„	Phosphorus	0·16
„	Sulphur	1·79
	Rust and magnetite	0·30
	Chromite	0·51
	SiO_2	38·02
	MgO	21·31
	FeO	19·81
	CaO	2·42
	NiO	0·07
	Al_2O_3	4·17
	Na_2O	1·26
	K_2O	0·29
		99·95

[1] Uncorrected by blank determination.

2. *Metallic Portion.*

Iron	90·5
Nickel and cobalt[1] ...	9·5
Copper	trace
	100·0

3. *Silicates attacked by Acid.*

Of the material attacked by hydrochloric acid, 85·74 per cent. is composed of silicates, the rest being the oxides, sulphides and phosphides, and the free metals. The following values for the composition of the silicate portion are calculated from the experimental numbers given in § 19 :—

		Oxygen, per cent.		
SiO_2 ...	34·85 ...	18·46		
MgO ...	25·96 ...	11·28		
FeO ...	31·59 ...	7·03	18·7	
CaO ...	1·57 ...	0·44		
Al_2O_3 ...	3·80 ...	1·79		21·08
K_2O ...	0·27 ...	0·04		
Na_2O ...	1·96 ...	0·50		
	100·00			

4. *Silicates unattacked by Acid.*

Of the material not attacked by hydrochloric acid, 97·81 per cent. consists of silicates, the remainder being chromite. After deducting the latter, the following values are calculated from the experimental numbers given in § 20 :—

		Oxygen, per cent.		
SiO_2 ...	55·10 ...	29·19		
MgO ...	20·52 ...	8·27		
FeO ...	8·12 ...	1·80		
CaO ...	7·91 ...	2·26		15·94
Al_2O_3 ...	7·13 ...	3·34		
K_2O ...	0·43 ...	0·07		
Na_2O ...	0·79 ...	0·20		
	100·00			

[1] Cobalt was found to be present in very small amount. Manganese and zinc were shown to be absent.

The 'oxygen ratio' for the silicates attacked by acid approximates to 1 : 1, that for the unattacked silicates to 1 : 2. The principal silicates belong therefore for the most part to the types $R_2''SiO_4$ and $R''SiO_3$, corresponding with the olivine and pyroxene groups respectively. This result is in harmony with the observations on thin sections described above.

Mineralogical Composition.

§ 26. From the foregoing results the following statement of the mineralogical composition of the meteorite may be deduced:—

Metallic alloys	5·80
Troilite	4·92
Schreibersite	1·06
Chromite	0·51
Magnetite and rust...	0·30
Silicates: [1]	
Olivine	53·47
Pyroxenes and felspars	33·89
	99·95

III. Relationship in Composition to other Chondritic Meteorites.

§ 27. The Chandakapur stone falls into the large class of stony meteorites with a small percentage of metal, to which the chondrites of Chantonnay, Krähenberg, Waconda, Mauerkirchen, Montrejeau, Nerft, Pultusk, Stavropol, Girgenti, Makariwa, Knyahinya, &c., belong.

To some of these it bears a noticeable quantitative as well as qualitative resemblance in the minerals present, particularly to Makariwa, Krähenberg, Waconda, and Nerft.

In detail, however, Chandakapur has several interesting peculiarities of composition. For example, the constitution of its nickeliferous iron is not in harmony with the empirical rule of W. Flight, which states that the alloys are richer in nickel the more sparingly they occur. If the series—Krähenberg, Girgenti, Pultusk, Hainholz—which are in ascending order of metallic content, be taken for comparison, the nickel-iron of Chandakapur should contain about 14 per cent. of nickel instead of 9·5 per cent.

[1] Including some 'glass', which, as shown by Ulrich, mainly passes into the attacked' portion.

Of more importance, however, are certain features of the composition of the silicates.

The most noteworthy points in the composition of the olivinic and pyroxenic silicates given above, are the comparatively large amounts of alumina in both, and the very marked difference between them in the proportion of iron to magnesium which they contain.

The ratio Fe : Mg in the unattacked part of Chandakapur is 1 : 4·6, and if the nomenclature adopted by Cohen[1] be used, the rhombic pyroxene will thus be a bronzite approaching enstatite. With this small ratio is associated a high alumina-value (7·13 per cent.), which seems to be a fairly regular feature in stones of this class. Thus in L'Aigle, Fe : Mg = 1 : 2·6 in the unattacked portion, and this latter contains 5·19 per cent. alumina. In the Chantonnay series (Knyahinya, Seres, Blansko) where Fe : Mg = about 1 : 3·5, there is about 6 per cent. of alumina. Further examples of this relation are found in the stones of Novo-Urei, Kernouve, Ställdalen, and Stavropol, where Fe : Mg varies between 1 : 4 and 1 : 5·3, and the alumina value is always high.

The largest proportions of alumina are found in the eucritic stones (e. g. Stannern, Jonzac, Juvinas, Sherghotty) where it is associated with lime, either in an augitic or anorthitic molecule. High alumina-values are, however, well known outside the class of the eucrites. Thus Brush found 8·05 per cent. alumina associated with only 0·67 per cent. alkali in the Waconda stone ; the alumina in this instance was present as anorthite. Results of a similar nature were obtained by Apjohn in the analysis of the Limerick meteorite.[2] The high proportion of lime and alumina associated together in the unattacked silicates of Chandakapur would seem to indicate the presence of a plagioclase-felspar or monoclinic pyroxene. The presence of the alkalis would also suggest that a portion of the alumina is contained in a felspar molecule ; but in view of the comparatively trifling amounts of augite and felspar recognizable in the sections, it seems probable that the alumina and lime may be present in one of the varieties of bronzite. It is also possible that a part of the alumina may occur in the glass-inclusions observable in the sections.

The silicate gelatinized by acid contains only a small amount of lime, and the iron and magnesium are present in the atomic proportion 1 : 2 An olivine of this form[3] (containing a little lime) was observed by von Baumhauer in the L'Aigle stone. It is the hyalosiderite of terrestrial

[1] E. Cohen, 'Meteoritenkunde,' 1894, Part i, p. 282.

[2] J. Apjohn, Journ. Chem. Soc., 1874, ser. 2, vol. xii, p. 103.

[3] $Fe_2SiO_4 . 2Mg_2SiO_4$.

olivines, and was said by Rammelsberg[1] to occur in eleven meteorites known to him, including Mauerkirchen, Montrejeau, Lancé, Parnallee, and Chassigny.

With the exception of the high values for alumina, which are not easily explicable, the general results obtained in the analysis harmonize fairly with the mineralogical composition observed in the microscopic sections.

Our thanks are due to Dr. S. J. Shand and to Mr. L. J. Spencer, for facilities to examine the specimens in the Royal Scottish Museum at Edinburgh, and in the British Museum, respectively; to the curators of numerous museums and other gentlemen, for information concerning the specimens in their collections; to Prof. E. A. Wülfing; and to Mr. A. Robinson, of the University Museum, for his skilful execution of the photographs reproduced in the plates.

Explanation of Plates.

Plate IX.

Fig. 1. Front view of the Chandakapur meteoric stone No. 3 (before cutting), showing crust and pittings. At the back is a fractured surface, roughly parallel to the front. The portion above the line *AA* is still preserved in the Oxford University Museum. (× $\frac{2}{3}$.)

Fig. 2. Section (× 14) showing an oval porphyritic olivine chondrule (*A*) with well-formed crystals and grains of olivine embedded in a granular, brownish matrix, and an outer shell of iron; *B* and *C*, chondrules containing olivine with bronzite; *D*, a small chondrule of bronzite with one large crystal and some smaller grains; *E*, a small chondrule showing a mosaic of fibrous bronzite.

Fig. 3. Section (× 14) showing a chondrule (*A*) with large porphyritic olivine crystals in compact greyish matrix; a granular olivine chondrule (*B*); *C*, a monosomatic olivine chondrule (section perpendicular to an optic axis) with concentric nucleus traversed by a network of glass (?); the semi-circular marking represents a rusty stain and shows the outline of the nucleus. *D* is a small oval chondrule, with shell of iron and compact radial-fibrous structure, of bronzite possibly with some monoclinic pyroxene.

Fig. 4. Section (× 14) showing a chondrule (*A*) with porphyritic olivine crystals elongated along the *c*-axis (tabular parallel to *b* (010) ?), in a compact greyish matrix; *B* and *C*, chondrules of granular olivine with iron shell; *D*, a porphyritic olivine chondrule with angular outline; *E*, a small chondrule resembling *D* in fig. 3.

Fig. 5. Section (× 14). *A*, a nearly monosomatic olivine chondrule with nucleus consisting of parallel crystals, elongated along the *c*-axis and probably

[1] C. F. Rammelsberg, Abhand. Akad. Wiss. Berlin, 1870, p. 138; 1879, p. 24.

tabular parallel to *b* (010), separated by layers of black glass, and a border partly in parallel position and partly granular, surrounded by a thin black line; a granular olivine chondrule (*B*); an irregular chondrule (fragment?) (*C*), formed of radiating prisms of monoclinic pyroxene. The sinuous white line represents a crack in the section.

Plate X.

Fig. 6. Section (× 14) showing a monosomatic chondrule (*A*) with nucleus containing regularly arranged glass inclusions and border enclosing opaque specks (see p. 357); *B*, a chondrule containing prisms of bronzite and grainsf olivine; *C*, a fragment of fibrous bronzite.

Fig. 7. Section (× 14) showing two large porphyritic chondrules, consisting (*A*) of bronzite prisms with a few grains of olivine, (*B*) of prisms of bronzite and olivine lying side by side.

Fig. 8. Section (× 14) showing (*A*) a large bronzite chondrule composed of several crystals cut in longitudinal and oblique directions; *B*, a sharply defined chondrule containing grains of olivine in a matrix of dark brown glass(?); *C*, a chondrule containing a large olivine crystal surrounded by small grains of bronzite.

Fig. 9. Section (× 14) showing (*A*) a broken, oval chondrule composed of two bronzite individuals with grating-structure due to enclosed layers of glass parallel to *a* (100) (section nearly parallel to c (001) for both crystals); *B*, a round chondrule of radial-fibrous bronzite with indented edge; *C*, portion of a chondrule formed of an intergrowth of two pyroxenes. (With crossed nicols.)

Fig. 10. Section (× 14) showing (*A*) a chondrule of fibrous bronzite with concave indentation; with small chondrules of granular olivine (*B*), bronzite prisms (*C*), and a large crystal of olivine bordered by segmental crystals of bronzite (*D*). (With crossed nicols.)

Fig. 11. Section (× 14) showing (*A*) a fragment of grey fibrous bronzite with light yellowish border; *B*, a chondrule of large radiating crystals of α- and γ-bronzite enclosing small grains of olivine; *C*, a chondrule of granular olivine with triple border of black inclusions; *D*, small chondrule composed of grains of olivine and β-bronzite.

Notes on the occurrence of zeolites in Cornwall and Devon.

By Arthur Russell.

[Read November 12, 1907, and March 15, 1910.]

IN the present notes the writer has endeavoured to collect all the available facts concerning the occurrence of zeolites in both Cornwall and Devon. Specimens belonging to this group are rarely represented in collections of Cornish minerals, and as several new localities have recently come to light, the following observations will, he ventures to hope, be of some interest as adding to the already lengthy list of mineral species occurring in the West of England.

Heulandite.

Wheal Forest, Okehampton, Devon.—During the summer of 1906, while mineral-collecting in the neighbourhood of Okehampton, Devon, I visited some small abandoned mine-workings named Wheal Forest, situated in Meldon Gorge, on the right bank of the West Okement River, about half a mile up from the viaduct. On the old burrows, in addition to some large and excellent crystals of axinite and garnet, I obtained several specimens of an unrecognized crystallized mineral. On my submitting the specimens to Mr. L. J. Spencer, he very kindly measured a crystal and showed the mineral to be heulandite, this being the first record of its occurrence in England.

On five of the specimens, which were all broken from one large mass, the heulandite presents itself as a thin crust of somewhat confused pearly crystals upon a peculiar, pale yellowish-brown rock, sections of which were examined and found to consist almost entirely of a plagioclase-felspar near oligoclase, with here and there small colourless prisms of apatite. On another of the specimens the heulandite forms druses of sharp and brilliant crystals, occupying cavities in the above-mentioned rock, the largest crystal noted being about 2 mm. in length. On a third specimen the heulandite occurs in very minute crystals forming a drusy crust on small crystals of quartz and pink orthoclase, associated with some mispickel.

The crystals are flattened parallel to the face *b* (010) and possess the characteristic pearly lustre. The face *c* (001) is usually uppermost. The following forms were observed *b* {010}; *c* {001}; *m* {110}; *t* {201}; *s* {$\bar{2}$01} (fig. 1). The specific gravity = 2·16.

According to an old mining directory, Wheal Forest was worked for copper, tin, lead, and arsenical pyrites about the year 1870.[1] Judging, however, from the small size of the burrows, very little work can have been done there. The mine is situated practically on the line of contact between the great granite boss of Dartmoor and the shales of the Culm-measures, and as in all other mines in the Okehampton district, the occurrence of axinite and garnet is attributable to powerful metamorphic agencies, evidence of which is to be seen on all sides. The heulandite is evidently of secondary origin and possibly derived from the associated and more or less altered plagioclase-felspar.

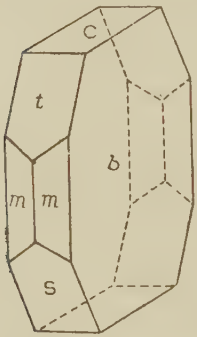


Fig. 1.—Crystal of Heulandite from Wheal Forest, Okehampton, Devon.

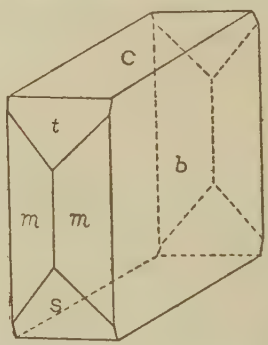


Fig. 2.—Crystal of Heulandite from Carrick Du mine, St. Ives, Cornwall.

Carrick Du mine, St. Ives, Cornwall.—During the summer of 1909 heulandite was found by the writer at the above locality. The mineral occurs in comparative abundance amongst the debris from an old shaft situated on the edge of the cliff, close to the footpath leading from St. Ives to Burthallan Cliff. The heulandite crystals form a crust, often covering considerable surfaces, on the joints of a greenish-grey, fine-grained, intrusive greenstone (diabase), a little foliated chlorite and also actinolite being present on some specimens. In one case the heulandite forms a coating on a mass consisting of quartz, pink orthoclase, chalybite, and chalcopyrite—evidently true lode-material.

The crystals possess a strong pearly lustre, owing to the prominence

[1] J. Williams, 'The Cornwall and Devon Mining Directory,' 1870, p. 85.

of the cleavage-face *b* (010), which face is perpendicular to the acute, positive bisectrix. They are mostly of a yellowish-brown colour, though sometimes quite colourless; they are well defined, and are occasionally 1 mm. in length, though usually much smaller. In habit they for the most part resemble the heulandite from Wheal Forest, Okehampton, and show the same forms *b* {010}; *c* {001}; *m* {110}; *t* {201}; *s* {$\bar{2}$01}. Some of the crystals, however, appear nearly square in outline (fig. 2), and thus resemble both in habit and colour the so-called beaumontite from Jones's Falls, Baltimore, Maryland, U.S.A. The specific gravity = 2·16.

Carrick Du mine was worked for copper and tin, but was abandoned about 1861.

Ramsley mine, South Tawton, Devon.—Heulandite was discovered at this locality by the writer during 1909. Only three specimens were found, all part of a single mass, which was obtained from the principal dump, and evidently derived from the deep workings of the mine. The crystals, which form a crust on a dark Culm-measures shale, are extremely small, barely 1 mm. in length, but are bright and fairly well defined. They are colourless, with the face *t* {201} prominent, and resemble in habit, and exhibit the same forms as the heulandite described from Wheal Forest and Carrick Du mines.

Stilbite.

The Cliffs between Wheal Cock and the Crowns Rock, Botallack, St. Just, Cornwall.—Joseph Carne in 1822 was the first to call attention to the occurrence of zeolites in the St. Just district. Stilbite is mentioned by him as occurring crystallized in flat four-sided prisms with wedge-like summits, associated with radiated mesotype and asbestos in prehnite veins.[1]

The area of cliff in which the prehnite veins occur is that lying between Wheal Cock on the north and the Crowns Rock, Botallack, on the south. The veins traverse a narrow strip of greenstone, which has intruded itself through the granite mass, and forms the precipitous cliffs between the two above-mentioned places. The writer has never seen a specimen of stilbite from this or other of the St. Just localities in any collection of Cornish minerals. It is, however, probable that the original locality might be re-found were a careful search made along the area of cliff in question.

[1] Joseph Carne, 'On the mineral productions and the geology of the parish of St. Just.' Trans. R. Geol. Soc. Cornwall, 1822, vol. ii, p. 310.

Hall in his 'Mineralogist's Directory' gives Botallack and Wheal Cock mines, St. Just, as a locality for stilbite.[1] There is, however, no evidence to show that stilbite occurred in the underground workings, the true locality probably being the cliffs between the two mines, as cited by Carne.

Colcerrow quarry, Luxulyan, Cornwall.—Mr. F. H. Butler was, I believe, the first to notice the occurrence of stilbite at this locality. Of this mineral only a few specimens have been found. In those that I have examined, the stilbite occurs as small, sheaf-like aggregates, or more rarely as distinct, colourless, glassy crystals reaching 6 mm. in length. It is associated with apatite, tourmaline, and quartz, and is implanted on small spheres of greenish-yellow gilbertite, which in turn coat large crystals of orthoclase, the whole occupying cavities in the coarse pegmatitic granite typical of the quarry.

The crystals are twinned in the manner common to stilbite, are flattened parallel to b (010), and are much elongated parallel to the zone $[c, b]$, with a tendency to group themselves in parallel position. The following forms were observed c {001}, m {110}, b {010}, f {$\bar{1}$01}. Of the five associated minerals the stilbite appears to have been the last formed, and there can be little doubt as to its secondary origin from felspar.

Chabazite.

Colcerrow quarry, Luxulyan, Cornwall.—Quite recently, the writer and Mr. F. H. Butler, while looking over a series of specimens from the Colcerrow quarry, Luxulyan, that formerly belonged to Mr. Warburton, of Highbury, noticed one showing a mineral that on examination proved to be chabazite.

The chabazite crystals, the largest of which is 3 mm. along the side, are perfectly transparent and colourless, and consist of simple rhombohedra r {10$\bar{1}$1}, faintly striated parallel to their edges. The specific gravity = about 2·1. A qualitative test revealed the presence of silica, alumina, lime, and water. The chabazite is associated with some small quartz crystals and occupies a cavity in pegmatitic granite, the occurrence being very similar to that of the stilbite already described.

According to a label with the specimens, they were obtained during 1892 and 1893. The Colcerrow quarry is already well known to mineral collectors for the fine specimens of apatite, fluor, &c., that it

[1] Townshend M. Hall, 'The Mineralogist's Directory,' 1868, pp. 43–44.

has yielded, but so far as the writer is aware the mineral chabazite has not previously been recorded from Cornwall.

Ramsley mine, South Tawton, Devon.—While examining the burrows of this mine in 1906, I discovered a single specimen of chabazite, a mineral not previously recorded from Devon. In 1909 a further examination resulted in the discovery in situ of a considerable number of excellent specimens. The exact spot at which the mineral was found is amongst the débris derived from the excavation of a small reservoir situated on the 800-feet contour line (Six-inch Ordnance Map, LXXVII. N.E.) on the west side of Ramsley Hill.

The chabazite crystals, which are thickly scattered over the surfaces or joints of a greenish-grey rock composed of hornblende and felspar (uralite-diabase), are small, the largest being not more than $1\frac{1}{2}$ mm. along the side; they are, however, very sharp and bright, and consist of colourless, glassy, simple rhombohedra, r $\{10\bar{1}1\}$, most of them showing the characteristic interpenetration-twinning. Many of the crystals are of composite growth and show two or more interpenetrating individuals. The forms e $\{01\bar{1}2\}$ and s $\{02\bar{2}1\}$ were observed on a few crystals. Associated with the chabazite are a few long, prismatic crystals of calcite m $\{10\bar{1}0\}$, terminated by the scalenohedron v $\{21\bar{3}1\}$. Minute, silky tufts of an undetermined mineral were also observed on a few specimens.

The Ramsley or, as it was formerly called, the Emily or Fursdon mine has been, and is still, extensively worked for copper on lodes traversing the shales of the Culm-measures, close to their junction with the great granite boss of Dartmoor. The lodes contain in addition to chalcopyrite, mispickel, and pyrrhotite, much axinite, garnet, diallage, and calcite, minerals that are common to highly metamorphosed areas. It is owing to the kind facilities offered to me by the joint-owner Mr. M. E. Jobling, and by the manager Mr. C. E. Jobling, that I have been able on several occasions to examine the surface and underground workings of this most interesting mine.

Analcite.

Cliffs near Botallack, St. Just, Cornwall.—Mr. J. H. Collins, in his 'Mineralogy of Cornwall and Devon,' states that analcite is said to have been found in the cliffs near Botallack.[1] The authority, however, is not given, and the occurrence must therefore be looked upon as doubtful. No specimen so labelled is known to the writer.

[1] J. H. Collins, 'Mineralogy of Cornwall and Devon,' 1871, Part II, p. 5.

Natrolite.

Chynhalls Point, St. Keverne, Lizard, Cornwall.—Mr. Harford J. Lowe described the occurrence of natrolite at Chynhalls Point, St. Keverne, in a paper read before the Geological Society of Cornwall in 1899.[1] According to him 'the natrolite occurs in needle-like crystals radiating from many centres, and occupies a narrow fissure, varying in width from an inch and a half to a mere joint in the vertical face of serpentine'. The mineral was chemically determined as natrolite by Dr. G. T. Prior. The occurrence is of interest, and the writer is unaware of the mineral having been previously found in serpentine-rocks.

Parc Bean Cove, Mullion, Lizard, Cornwall.—As an associate of datolite, described by Mr. W. F. P. McLintock at the meeting on March 15, 1910, of this Society (this vol., p. 407).

Apophyllite.

Terrace Hill quarry, Lostwithiel, Cornwall.—Three specimens found by the writer at this locality during 1907 show a mineral which is apparently apophyllite. The mineral occurs in small, white, semi-transparent, lamellar masses possessed of a very strong pearly lustre, and is more or less completely embedded in a skeleton-like mass of a slightly less pearly, opaque material, which also contains numerous embedded, sharp crystals of violet-brown axinite. The other minerals present on the specimens are yellowish-brown garnet, massive and in small crystals, small masses of deeply-etched calcite, quartz, black blende, galena, and a few specks of iron-pyrites.

Before the blowpipe the apophyllite is easily fusible to a white, bubbly enamel, and yields water in a closed tube. It is decomposed by hydrochloric acid with the separation of silica, gives a slight precipitate with ammonia, and a copious precipitate with ammonium oxalate. The solution gives a micro-chemical reaction for potassium with platinum chloride. The specific gravity = 2·31. Cleavage fragments show a positive, uniaxial figure with weak double refraction.

Terrace Hill quarry is situated a little to the north of the town of Lostwithiel, and has long been known as one of the best localities in Cornwall for crystallized axinite. The rock is a very tough calc-flinta.

[1] H. J. Lowe, 'Natrolite from the Coverack district.' Trans. R. Geol. Soc. Cornwall, 1900, vol. xii, pp. 336–337.

The following is a list of so-called zeolites that have been mentioned by various writers on Cornish mineralogy. It includes many doubtful occurrences, and in nearly every case the description given is too vague to make it possible to assign the substances described to any recognized species.

In 'A Manual of Mineralogy', published at Truro in 1825,[1] two zeolites are mentioned under the headings of zeolite and mesotype as occurring in Stenna Gwyn mine, St. Stephen's. The writer has been unable to find any specimens from this locality in any Cornish collection, and it seems more than likely that the so-called zeolites were really the mineral wavellite, the occurrence of which has long been known at this mine. The Stenna Gwyn wavellite occurs in granite as delicate radiating tufts of acicular crystals which might easily have been mistaken for a zeolite. Townshend M. Hall, whose information was probably derived from the above source, gives Stenna Gwyn as a locality for both natrolite and mesolite.[2]

Greg and Lettsom cite 'Wheal Carn' as a locality for natrolite.[3] This, however, is most probably a confusion with 'Wheal Cock Carn', a name formerly used for an elevated portion of the cliff close above the prehnite vein, and given as a locality for apatite by Joseph Carne in his account of the St. Just minerals. There is an old tin mine in the granite, named Wheal Carne, about a mile inland east of Wheal Cock, where the mineral 'isopyre' was first noticed by Carne; of zeolites, however, he makes no mention. Hall falls into the same error as Greg and Lettsom, at the same time naming prehnite, stilbite, and axinite as occurring at Wheal Carne, St. Just.[4]

A mineral described as 'radiated mesotype', and which sometimes contained nodules of prehnite, also an earthy variety, possibly the 'mealy zeolite' of Jameson, are stated by Carne to have accompanied stilbite in the prehnite vein in the cliff between Wheal Cock and

[1] 'A Manual of Mineralogy; in wich [*sic*] is shown how much Cornwall contributes to the illustration of the science.' Truro, 1825, pp. 175-176. This admirable, but little-known work on Cornish mineralogy was published anonymously, likewise a later edition in London, 1828. A presentation copy is, however, known to the writer in which the name of the author is given as Thomas Hogg, Master of the Grammar School, Truro. This was also stated in some copies issued in 1826 with a fresh title-page (Truro, 1826). William Jory Henwood (Trans. R.Geol. Soc. Cornwall, 1871, vol. viii, part 1, p. 112) in quoting extracts, wrongly ascribed the book to Michell.

[2] Townshend M. Hall, 'The Mineralogist's Directory,' 1868, p. 33.

[3] R. P. Greg and W. G. Lettsom, 'Manual of the Mineralogy of Great Britain and Ireland,' 1858, p. 151.

[4] Townshend M. Hall, loc. cit., p. 44.

Botallack.[1] Carne also mentions 'needlestone' as having occurred at Botallack;[2] it is not, however, clear whether this refers actually to the mine or the cliff locality near by. Greg and Lettsom state that natrolite occurred occasionally with prehnite between Botallack and Wheal Cock.[3] Hall mentions mesolite from the same locality.[4]

[1] Joseph Carne, 'On the mineral productions and the geology of the parish of St. Just.' Trans. R. Geol. Soc. Cornwall, 1822, vol. ii, p. 310.

[2] Joseph Carne, 'Additional contributions to the mineralogy of the parish of St. Just.' Trans. R. Geol. Soc. Cornwall, 1846, vol. vi, p. 48.

[3] R. P. Greg and W. G. Lettsom, loc. cit., p. 151.

[4] Townshend M. Hall, loc. cit., p. 43.

Analyses of Seligmannite, zinciferous Tennantite ('Binnite'), and Fuchsite from the Lengenbach quarry, Binnenthal.[1]

By G. T. Prior, M.A., D.Sc., F.G.S.

Keeper of Minerals in the British Museum.

[Read June 16, 1908.]

(1) The chemical composition of Seligmannite.

THE crystallographic and other physical characters of seligmannite from the well-known quarry in the Lengenbach, Binnenthal, were first described by Professor Baumhauer in 1901.[2] In its crystallographic characters the mineral was found to be closely allied to bournonite, which it resembled in the habit of the crystals and the repeated twinning on the prism-planes. The axial ratios for the two minerals as given by Baumhauer are:—

Seligmannite, $a : b : c = 0{\cdot}92804 : 1 : 0{\cdot}87568$
Bournonite, $a : b : c = 0{\cdot}93798 : 1 : 0{\cdot}89688$

Seligmannite was therefore regarded by Baumhauer as isomorphous with bournonite, and as being probably the corresponding arsenic compound having the formula $Cu_2S.2PbS.As_2S_3$. The amount of material at his disposal seems to have been insufficient for a chemical examination. Small crystals, however, which were found on dufrenoysite and described in 1902[3] by Mr. R. H. Solly, were tested at Cambridge by Dr. H. J. H. Fenton and found to contain copper, lead, sulphur, and arsenic. Since that time a few more crystals of this rare mineral, including the large crystal described in 1905,[4] have been found by Mr. Solly. On this material the two following quantitative chemical analyses have been made, the result of which has been to confirm completely Baumhauer's suggestion as to the isomorphism of seligmannite and bournonite.

The first analysis (I) was made on crystal fragments picked out by Mr. Solly, and the second (II) on a portion of the large crystal previously mentioned.

[1] Communicated by permission of the Trustees of the British Museum.
[2] H. Baumhauer, Sitzungsber. Akad. Wiss. Berlin, 1901, pp. 110-117.
[3] R. H. Solly, Mineralogical Magazine, 1903, vol. xiii, pp. 336-339.
[4] R. H. Solly, Mineralogical Magazine, 1906, vol. xiv, pp. 186-187.

The results of the analyses are as follows :—

	I.	Atomic ratios.	II.	Atomic ratios.
Pb	46·34	0·225	48·83	0·236
Cu	13·09	0·208	10·51	0·164
Ag	0·11	0·001	0·23	0·002
Zn	0·27	0·004	—	—
Fe	0·06	—	0·80	0·015
As	16·88	0·225	16·94	0·226
Sb	0·64	0·005	0·71	0·006
S	21·73	0·677	22·01	0·705
	99·12		100·03	

The weight of the material used in I was 0·5187 gram, and its specific gravity 5·44 ; the weight used in II was 0·5432 gram, and its specific gravity 5·48.

The result of analysis I agrees very closely with the formula $2PbS.Cu_2S.As_2S_3$, that of II not quite so closely ; but there is reason to suppose that the material of the large crystal used in II was not so pure as the crystal fragments used in I. The analyses, without doubt, confirm the idea suggested by the crystallographic characters of the mineral that seligmannite is the arsenic analogue of the sulph-antimonite bournonite.

(2) Analysis of zinciferous Tennantite ('Binnite').

Amongst other specimens found by Mr. Solly some years ago at the Lengenbach quarry, was a large cubic crystal with faces about 15 mm. across, and deeply striated parallel to their intersections with small tetrahedral faces. Other crystals were afterwards found presenting similarly striated cube-faces, but with the tetrahedral planes more fully developed. In the development of the faces, therefore, the mineral differs from the ordinary tennantite or binnite of the Binnenthal, and a chemical analysis seemed desirable. The result of the analysis which was made is as follows :—

	I.	II.	Combined.	Atomic ratios.
Cu	42·03	—	42·03	0·670
Ag	—	1·24	1·24	0·011
Zn	—	7·76	7·76	0·119
Fe	—	0·62	0·62	0·011
As	19·80	—	19·80	0·265
S	—	28·08	28·08	0·878
			99·53	

The weight of material used in I was 0·2367 gram; in II, 0·5089 gram. The specific gravity was 4·61.

The analysis shows that the mineral is tennantite containing a large percentage of zinc, to which possibly the unusual habit of the crystals may be due.

The mineral is referred to in Léon Desbuissons's 'La Vallée de Binn', 1909, pp. 124, 184.

(3) Analysis of Muscovite (Fuchsite).

This mineral is referred to in Léon Desbuissons's 'La Vallée de Binn', 1909, pp. 65, 164, 184. It occurs at the Lengenbach quarry as clear green crystals in the dolomite.

The material for the following analysis was supplied by Mr. Solly. The result is as follows:—

SiO_2	47·24
Al_2O_3	31·86
Cr_2O_3	0·87
FeO	0·56
CaO	0·58
MgO	2·91
K_2O	10·72
Na_2O	0·16
Li_2O	0·14
Loss on ignition ...	5·37
	100·41

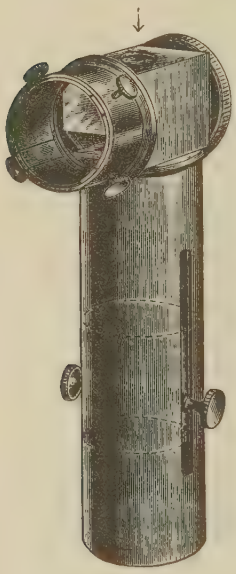
The weight of material used in the main analysis was 0·5010 gram; for alkalis, 0·4192 gram. The Cr_2O_3 was determined colorimetrically.

A camera lucida attachment for the goniometer.

By G. F. Herbert Smith, M.A., D.Sc., F.G.S.
Assistant in the Mineral Department of the British Museum.

[Read June 16, 1908.]

WHEN investigating the morphology of crystals, such as those of schwartzembergite, which are so rounded or striated as to afford no definite reflections of the object-slit of the goniometer, the author found most serviceable a camera lucida which could be attached to the eye-piece of the telescope of the goniometer, and thus used for the direct drawing upon paper of the 'light-figures' given by the crystals, the ordinary signal being replaced by a pin-hole. The cap of the eye-piece in use is unscrewed and the camera lucida is fixed to the tube by means of four clamping screws. The camera lucida is of the ordinary type, consisting of the Amici double-prism, so that the eye looks vertically downwards upon the paper of the drawing, while the image that would ordinarily be visible in the eye-piece is projected in the same direction. The only modification is the additional vertical tube, within which is an inner tube carrying a lens that brings the drawing sharply into focus and removes the parallax that otherwise exists between the image and the drawing. The inner tube can be held in any desired position by means of two clamping screws which pass through the vertical slots of the outer tube and grip it. The lens is carried in a cell, and may be removed by unscrewing the ring fixing it, and replaced, if necessary, by another of more suitable focal length for the purpose in view.



Camera lucida attachment for the goniometer.[1] (The arrow indicates the direction of vision.)

The camera lucida is of service for two purposes:—

1. *The representation of 'light-figures'.*—Imperfectly formed crystals with rounded or striated faces are not suitable for measurement in the

[1] The block for this figure has been kindly lent by Dr. A. E. H. Tutton, F.R.S., with the permission of Messrs. Macmillan & Co., Ltd., the publishers of his forthcoming book on crystallography.

ordinary way, and the determination of the position-angles of even a few conspicuous parts of the 'light-figures' would be a tedious operation. By means of the camera lucida the figures may be drawn directly upon a projection if a two- or three-circle form of goniometer be employed. The most convenient course is to map out the projection by parallels referred to the centre of the projection, the distances remaining constant for each revolution. The crystal should be revolved a convenient number of degrees—10°, 15° or 20°—at a time, and the drawing revolved simultaneously through the same angle. The scale of magnification is determined by the known angular width of the field of the telescope of the goniometer; it must, however, be remembered that the angular distance between two images in the field of the telescope is double that actually subsisting between the corresponding small faces, and therefore for the purposes of the projection the angular width of the field must be taken as half its actual value. A lens of suitable focal length must be selected to fit the scale; slight modifications can be secured by raising or lowering the paper slightly, or by revolving the eye-piece through a small angle so that the tube of the camera lucida is slightly out of the vertical. In the case of the stereographic projection the linear equivalent of angular distance is at the equatorial plane just double that near the pole. The longer the focal length of the lens used with the camera lucida, the larger the scale of the projection.

2. *The delineation of small crystals.*—With any form of goniometer which admits of the simultaneous determination of the distance and azimuth of the poles of a crystal with respect to a fixed pole as origin, no difficulty is experienced in determining the relative positions of the faces developed on a crystal, however tiny and complex it be, once it has been mounted on the crystal-holder; but the faithful drawing of such a crystal and the correct identification of the faces is not easy in the ordinary way. If the crystal be drawn by means of a camera lucida under a microscope it may be impossible to recognize with certainty, from the freehand sketches previously made, the faces depicted. No such difficulty exists if the crystal be drawn while still on the goniometer, since in any case of doubt the co-ordinates of the particular face may be at once re-determined. A small portable electric lamp to illuminate the crystal from different points will be found useful. The author has also found it convenient to have an attachment for converting the telescope into a microscope by placing before the eye-piece a lens which has a sliding arrangement for focusing purposes. The longer the focal length of the lens used with the camera lucida, the larger the resulting drawing.

Twin-planes and cross-planes.

By John W. Evans, LL.B., D.Sc., F.G.S.

Imperial Institute and Birkbeck College.

[Read January 21, 1908, and January 26, 1909.]

IN a single homogeneous crystal the physical character of parallel lines are everywhere the same, and it may be justifiably assumed that the orientation of the crystal-structure is constant throughout. Compound crystals, however, occur in which the orientation of the crystal-structure is different in different parts although they consist of the same substance.[1]

This difference of orientation may either be original or result from the action of mechanical forces on the crystal-structure. I shall in the first place assume that the former is the case.

In many occurrences there does not appear to be any significant relation between the orientation of the structure in adjoining portions, and we may conclude that their relative orientation was determined before the progress of crystallization brought them into contact. In other cases there is a simple geometrical relation between the two component structures, and it is reasonable to suppose that the crystallization of one or both started from the surface where they are in contact and that the orientation of the structure of one was influenced by that of the other.

The surface of contact or composition is then usually a plane, the plane of composition, which is in the greater number of cases a possible crystal-face.

The nature of the relation between the two structures that may be expected to exist in the plane of composition is indicated by the results of Mr. T. V. Barker's[2] studies of similar combinations of crystals of two different substances. He has shown that such substances unite with regular relative orientation only where there are certain lines[3] in the plane of composition in which the molecular distances in the two crystals

[1] Enantiomorphic substances are considered to be the same for the purpose of this communication.

[2] T. V. Barker, Mineralogical Magazine, 1907, vol. xiv, pp. 235–257.

[3] The word 'line' is here used in a general sense including all parallel lines, viz. as possessing orientation but not position.

are approximately equal, or those of one are approximately multiples of those of the other.

A similar relation should hold in the plane of composition in combinations of two portions of the same substance with different but related orientation.

The simplest, and therefore probably the most frequent, case will be that in which the molecular distances are exactly equal in the two component structures along one or more lines in the plane of composition. Such a line will obviously represent the coincidence of equivalent lines in the two structures, of which they will be possible crystal-edges, for they both represent rows of molecules.

A line in which equivalent lines, whether possible edges or not, of the two component structures of a compound crystal coincide, may be conveniently referred to as a *common line.*

If the equivalent directions in the two lines coincide, the common line may be said to be *co-directional.* If, on the other hand, the equivalent directions of uniterminal lines are opposed, the common line is *contra-directional.*

We may expect by analogy with the combinations of unlike substances that there will usually be at least two common lines in the plane of composition, each made up of equivalent lines which are possible crystal-edges of the component structures.

If this be the case, the plane of composition must represent two equivalent planes in the component structures, of which they will be possible faces.

A plane in which two equivalent planes, whether possible faces or not, coincide, may be termed a *common plane.*

In some cases all the lines in a common plane are common lines, that is to say, not only are the two equivalent planes co-planar, but all lines in the one are co-linear with equivalent lines in the other.[1]

The common plane then constitutes what is known as a *twin-plane*: provided, of course, that the two structures are not parallel in all respects.

If all the common lines of a twin-plane are co-directional, the twin-plane may be described as co-directional. If, on the other hand, those which represent the coincidence of uniterminal lines are contra-directional, the twin-plane may be said to be contra-directional.

If, on the other hand, a common plane contain only a limited number of common lines,[2] it can be shown that there may be two, four, or six, but

[1] Cf. Max Schuster, Zeits. Kryst. Min., 1886, vol. xii, p. 141.

[2] Cf. Max Schuster, loc. cit.

no other number of common lines, and that these occur in pairs such that the members of a pair are at right angles to each other.

The common plane may then be appropriately described as a *cross-plane*.

In common planes which are neither twin-planes nor cross-planes there are no common lines.

So far, the terms common plane, twin-plane, and cross-plane have been applied only to a plane of composition, and the term common line only to a line in that plane. The same terms may, however, be conveniently extended to all planes and lines[1] in which there are similar relations between equivalent parallel planes and lines in the two component structures.

The common planes, twin-planes, or cross-planes which are planes of composition, may be termed *contact common planes*, contact twin-planes, or contact cross-planes; and those that are not planes of composition may be termed *abstract common planes*, abstract twin-planes, or abstract cross-planes. In the same way, a common line in the plane of composition may be termed a contact common line, and one which does not lie in a plane of composition an abstract common line.

The normal to every common plane is a common line, and vice versa every plane at right angles to a common line is a common plane. A common line at right angles to a twin-plane is called a twin-axis.

It can be shown that every plane at right angles to a twin-plane is either a twin-plane or a cross-plane, and that there is at least one twin-plane at right angles to every cross-plane.

Every compound crystal which possesses a twin-plane may be described as a twin-crystal.

Where the plane of composition is not a possible crystal-face it appears to be always a cross-plane and to contain only one common line, which is a possible crystal-edge of the component structures and in which the molecular intervals coincide. The other common line at right angles to the first is parallel to the intersection of the plane of composition with a possible face in each component, such faces being equivalent to one another.

Parallel to these faces are a succession of plane-nets of molecules which outcrop (if the expression may be used) in the plane of composition in

[1] See note, ante, p. 390. The use of the term 'common edge' or 'common face' in the case of parallel equivalent edges or faces in two structures is already recognized; see, for instance, Max Schuster, loc. cit.

parallel lines at equal intervals in the two structures, and it is the coincidence of these edges which determines the plane of composition.

For instance, in the pericline-twins of the plagioclase-felspars the plane of composition (the rhombic section) is a cross-plane containing only two common lines—the macro-axis and the line at right angles to it. The former is a possible crystal-edge and along it the molecular intervals exactly coincide in the two component structures. The common line at right angles to it is not a possible edge, nor is the cross-plane that forms the plane of composition a possible face. Its position is determined so that the second common line may lie in the brachypinacoidal cleavage, an important structural plane. The intergrowth accordingly takes place in such a manner that the edges of the plane-nets of molecules giving rise to the brachypinacoidal cleavage, which outcrop from the two component structures in the plane of composition, exactly coincide. Not only are these edges parallel, but the intervals between them are the same in the two component structures.

The outcropping edges of the plane-nets of molecules parallel to any hemi-prism (e. g. *l*) also coincide with those of the other corresponding hemi-prism (e. g. *T*); but these coinciding edges are not equivalent lines like the outcropping edges of the brachypinacoidal cleavage, and do not therefore form a common line. However, though not equivalent, they must be closely similar in physical characters, and it can be easily shown that the intervals between them are identical in both structures.

In these twins the twin-plane is at right angles to the plane of composition; and their line of intersection and the twin-axis are each one of the common lines in the plane of composition. The twin-plane in such a case possesses no structural importance.

It can be shown that every twin-crystal as thus defined can be obtained from two parallel structures by the application to one structure of one of the three following 'twinning operations':—(1) A reflection about a plane, or, as I prefer to describe it, a reversal relatively to a plane. This may be termed *plane-twinning*. The two structures are now symmetrical to the plane, which becomes a twin-plane. (2) A rotation through a half circle round a line, or, what comes to the same thing, a reversal relatively to a line. This is *line-twinning*, and the two structures may be said to be symmetrical to a line, which becomes a twin-axis. (3) Inversion or reversal relatively to a point. In this, which may be termed *point-twinning*, the two structures are symmetrical to a point; every plane is a twin-plane and every line a twin-axis.[1]

[1] Point-twinning is referred to by G. Linck ('Grundriss der Krystallographie,' 1896, p. 24) and H. A. Miers ('Mineralogy,' 1902, pp. 91 and 371), who term it alternating twinning. Curiously enough, the former states that no example is known. As a matter of fact, it is found in quartz, pyrargyrite, nepheline, hemimorphite, sodium chlorate, chalcopyrite, and other crystals belonging to the same classes.

There can be obviously no plane-twinning about a plane which is a plane of symmetry in the untwinned crystal, no line-twinning about a line which is a line of symmetry,[1] and no point-twinning where there is a centre of symmetry.

In most cases the same twin-crystal may be referred to two of the three categories or modes of twinning above mentioned. For instance, if a twin-crystal show point-twinning, there will be plane-twinning about every plane at right angles to a line of symmetry[2] and line-twinning about every normal to a plane of symmetry. Again, if there be a centre of symmetry, the same twin-axis and twin-plane may be referred to both plane- and line-twinning.

Where a twin-crystal possesses more than one twin-plane and axis the question arises as to which shall be selected for descriptive purposes. If there be a plane of composition which is a twin-plane, it is convenient to select it as the principal twin-plane and its normal as the principal twin-axis. If there is no plane of composition which satisfies this condition, it is best to select as twin-axis the line which has the highest symmetry in the untwinned crystal.

A similar question arises where a twin-crystal may be explained by more than one mode of twinning. Where point-twinning exists it is more important than the plane- or line-twinning, if any, that accompanies it, for it is independent of the line selected as twin-axis and corresponds to a simple fundamental relation—the reversal of every direction in one component crystal compared with the other. Where there is a centre of symmetry, and every twin-axis is an axis of both plane-twinning and line-twinning, the former is the more convenient conception for purposes of exposition. Reversal relatively to, or reflection about, a twin-plane is more easily recognized than reversal relatively to (or rotation through a half turn round) a twin-axis. The former, as pointed out by V. Goldschmidt,[3] has a genetic significance,[4] while the latter is open to misconception by the elementary student.

In the same way, where the choice lies between an axis of plane-twinning and one of line-twinning, the former should be chosen, unless

[1] If complete self-coincidence can be obtained by a reversal relatively to a line or rotation through a half circle round it, the line may be termed a line of symmetry.

[2] As for instance in the *a* laevodextrogyral or 'Brazilian' twins of quartz.

[3] V. Goldschmidt, Zeits. Kryst. Min., 1898, vol. xxx, p. 254.

[4] Such twins are also explained by a symmetry about a plane by Max Schuster, Zeits. Kryst. Min., 1886, vol. xii, pp. 139 and 147, and by H. A. Miers, 'Mineralogy,' 1902, p. 87.

he latter is at right angles to a plane of composition or possesses higher ymmetry.

We may now proceed to consider compound crystals with more or less efinite relations between the component structures, but in which there s no twin-plane.

In the first place, they may have a plane of composition which con-ains one and only one common line and is therefore not a common plane ormed by the coincidence of equivalent planes in the two structures. uch compound crystals comprise the combinations which are referred by V. Goldschmidt[1] as 'einzonige' or 'einkantige Verwachsungen'. xamples are furnished by groups of prismatic crystals with no definite elations except the parallelism of the axes of the prisms.

In another class of cases the plane of composition is a common plane ormed by the coincidence of equivalent planes, which contains no common nes and is therefore neither a twin-plane nor a cross-plane. The normal, owever, is a common line. These combinations are described by Gold-chmidt[2] as 'einflächige Verwachsungen'. Examples are found where mall crystals of quartz, flattened parallel to a prism-face, adhere to a rism-face of a larger crystal of the same mineral without any other efinite relative orientation.

Both classes of combinations are grouped together by Goldschmidt nder the name of 'einachsige Verwachsungen', which may be rendered unilinear combinations', for they possess one common line, either in he plane of composition or normal to it. Any other combination in hich there is a single common line may be included in the same ategory.

Such combinations may be conceived geometrically as the result of the otation of a portion of a simple crystal round any line, or of one of the two omponent structures of a twin-crystal round a common line, which may ither be the twin-axis or a line in the twin-plane; provided such rota-ion does not result in a twin-crystal or leave the two structures parallel. he axis of rotation will remain a common line. The plane at right ngles to it, though it remains a common plane, will not, by hypothesis, e a twin- or cross-plane. Miers[3] has described combinations of bournonite nd of pyrargyrite, which are at first sight true twins of those minerals ith crystal-faces as twin-planes, but which usually show a small

[1] V. Goldschmidt, Zeits. Kryst. Min., 1907, vol. xliii, p. 585.
[2] V. Goldschmidt, loc. cit.
[3] H. A. Miers, Mineralogical Magazine, 1884, vol. vi, p. 77; 1888, vol. viii, 75.

inconstant deviation from the theoretical relation. This deviation corresponds to a rotation through a small angle round either a crystal-edge in the theoretical twin-plane or round the theoretical twin-axis.

It can be shown, however, that, if one portion of a simple crystal be rotated round any line or if one component structure of a twin-crystal be rotated round a common line, the common plane at right angles to the axis of rotation will be a cross-plane, provided that (*a*) the two component planes which coincide in it are each symmetrical to a line in it, or (*b*) the cyclic order of the succession of equivalent lines is opposite in these two planes; unless of course the rotation converts the common plane into a twin-plane or the two structures are brought into a parallel position. The existence of such a cross-plane implies a plane at right angles to it which satisfies the definition of a twin-plane. In many cases, however, the common lines of the cross-plane have no structural significance and the compound crystal will not differ essentially from a unilinear combination. It may then be termed an *accidental twin-crystal*, and the twin-plane an accidental twin-plane.

The subject of the combination of differently orientated structures of the same substance in which there are no common lines, but merely lines with approximately equal molecular distances, does not fall within the scope of the present paper. They have been dealt with to some extent by Goldschmidt under the name of 'hetero-axiale Zwillinge' or 'Heterozwillinge',[1] and by Max Schuster[2] and Baumhauer.[3]

It only remains to consider combinations of differently orientated portions of a crystal substance which were originally parallel. There is no evidence that in any case one portion has moved as a whole relatively to the other (that is to say without change in the internal structure) so as to give rise to a definite geometrical relation between them.

There are, however, many compound crystals in which the structure of one portion has suffered a new arrangement of the molecules which is equivalent to a change of orientation of the structure. This change may be the result of (*a*) external forces, or (*b*) internal stresses due to crystallization or change of crystal-structure under conditions of constraint. In the latter case the rearrangement of the molecules may be but slightly posterior to the formation of the crystal-structure itself.

In the majority of cases the movement of the molecules is in the nature of a translation parallel to the plane of composition of the

[1] V. Goldschmidt, loc. cit.

[2] Max Schuster, Zeits. Kryst. Min., 1886, vol. xii, p. 149.

[3] H. Baumhauer, ibid., 1899, vol. xxxi, pp. 252–275.

resulting compound crystal, the amount of movement being proportional to the distance from it. The plane of composition, or gliding-plane as it is termed, will then satisfy the conditions of a twin-plane.

In other cases the movement appears to comprise a rotation as well as a translation, so that the plane of composition becomes a cross-plane with a twin-plane at right angles to it.

It is probable that all cases of lamellar twinning are essentially secondary, due to the action of mechanical forces on the crystal-structure.

Axes of symmetry and the crystallographic classes.

By John W. Evans, LL.B., D.Sc., F.G.S.

Imperial Institute and Birkbeck College.

[Read March 15, 1910.]

IT is usual to divide axes of rotatory symmetry into those of the first and those of the second sort. In the former a crystal is brought into coincidence by a rotation through a certain angle round the axis and in the latter by such a rotation followed by a reflection about (or, as I prefer to say, a reversal relatively to) the plane at right angles to the axis. In 1906 Mr. H. Hilton[1] proposed to define an axis of rotatory symmetry of the second sort as one in which the rotation was followed by an inversion about (reversal relatively to) a point, and he showed that his proposal would, if adopted, simplify the definition of the crystallographic classes.

The reason for this change is most easily understood if instead of distinguishing two kinds of axes we discriminate between two degrees of coincidence. For this purpose the crystallographic structure is considered as expressed by lines; of which the more important are obviously those parallel to possible crystal-edges or normal to possible faces.

In complete or *co-directional* coincidence not only are equivalent lines brought into coincidence but also equivalent directions in those lines. Whereas in incomplete or *contra-directional* coincidence equivalent lines coincide but the equivalent directions of uniterminal lines are brought into opposition to one another. Both kinds of coincidence may be described as co-linear coincidence, for in both equivalent lines coincide.

If a crystal can be brought into co-directional coincidence by a rotation through an angle $2\pi/n$ and no smaller angle, the axis will be in the language employed by Mr. Hilton an n-al rotation axis of the first sort, or, as I should prefer to call it, an axis of co-directional rotatory symmetry with cyclic number n.

If, on the other hand, the coincidence be only contra-directional, the axis will be in Mr. Hilton's words an n-al axis of the second sort, or, from my point of view, an axis of contra-directional rotatory symmetry

[1] H. Hilton, Mineralogical Magazine, 1907, vol. xiv, p. 261.

with cyclic number n. In both cases it may also be described as an axis of co-linear rotatory symmetry with the same cyclic number n.

It is easy to show that an axis of contra-directional rotatory symmetry with cyclic number n is an axis of co-directional rotatory symmetry with cyclic number $n/2$.

The use of these terms may be illustrated by the diagrams of crystals referred to in the following paper (p. 401) on 'A modification of the stereographic projection'.

In the holosymmetric class of the cubic system (1a and 1b) the crystallographic axes are axes of co-directional and co-linear rotatory symmetry with cyclic number 4. In the tetrahedrite class of the same system (2a and 2b) they are axes of contra-directional and co-linear rotatory symmetry with cyclic number 4 and axes of co-directional rotatory symmetry with cyclic number 2.

In the calcite class of the rhombohedral system the principal axis is an axis of co-directional and co-linear rotatory symmetry with cyclic number 3, whereas in the benitoite class of the same system it is an axis of contra-directional and co-linear rotatory symmetry with cyclic number 6 and one of co-directional rotatory symmetry with cyclic number 3.

In a paper on 'A simple arrangement and notation of the thirty-two classes of symmetry based on the symmetry of zone-axes' [1] I have given a table of crystallographic classes arranged according to the co-directional cyclic numbers of the axes of rotatory symmetry with the highest cyclic number, except in the case of the cubic symmetry where the four axes with cyclic number 3 are employed. The accompanying table is exactly similar except that it is based on the co-linear cyclic number, and the letter k indicates that the axis is one of contra-directional rotatory symmetry. Not only is the arrangement simpler, there being a smaller number of rows, but it has the advantage that all the members of a system appear in the same column: the first column comprising the triclinic, the second the monoclinic and orthorhombic, the third the tetragonal, and so on. The trigonal bipyramidal and ditrigonal bipyramidal (benitoite) classes find a place with the hexagonal instead of the rhombohedral (trigonal) classes. Groth's nomenclature is appended in each case.

Similar symbols may be employed to designate different types of rotatory axes, but for the sake of distinction Arabic instead of Roman numerals should be employed.

[1] J. W. Evans, Mineralogical Magazine, 1907, vol. xiv, pp. 360–364.

	Simple or one whole turn axis.	Digonal or one-half turn axis.	Tetragonal or one-quarter turn axis.	Trigonal or one-third turn axis.	Hexagonal or one-sixth turn axis.	Four trigonal or one-third turn axes.
Co-linear cyclic number.	I.	II.	IV.	III.	VI.	C = (4 × III)
System.	Triclinic.	Monoclinic and Orthorhombic.	Tetragonal.	Rhombohedral.	Hexagonal.	Cubic.
Unilateral (U). Uniterminal (u).	I Uu Asymmetric. *Calcium thio-sulphate.*	II Uu Sphenoidal. *Cane-sugar.*	IV Uu Tetragonal pyramidal. *Wulfenite.*	III Uu Trigonal pyramidal. *Sodium periodate.*	VI Uu Hexagonal pyramidal. *Nepheline.*	C Uu Tetrahedral-pentagonal-dodecahedral. *Ullmannite.*
Biterminal. Central (c).	I Uc Pinacoidal. *Albite.*	II Uc Prismatic. *Augite.*	IV Uc Tetragonal bipyramidal. *Scheelite.*	III Uc Rhombohedral. *Phenacite.*	VI Uc Hexagonal bipyramidal. *Apatite.*	C Uc Dyakis-dodeca-hedral. *Iron-pyrites.*
Contra-directional (k).	—	II Uk Domatic. *Clinohedrite.*	IV Uk Tetragonal bisphenoidal. *No example known.*	—	VI Uk Trigonal bipyramidal. *No example known.*	—
Helical (h).	(*See II Uu*)	II Uh Bisphenoidal. *Epsomite.*	IV Uh Tetragonal trapezohedral. *Strychnine sulphate.*	III Uh Trigonal trapezohedral. *α-quartz.*[1]	VI Uh Hexagonal trapezohedral. *β-quartz.*[1]	C Uh Pentagonal-icositetrahedral. *Cuprite.*
Bilateral (B). Uniterminal (u).	(*See II Uk*)	II Bu Pyramidal. *Hemimorphite.*	IV Bu Ditetragonal pyramidal. *Succin-iodimide.*	III Bu Ditrigonal pyramidal. *Pyrargyrite.*	VI Bu Dihexagonal pyramidal *Iodyrite.*	C Bu Hexakis-tetra-hedral. *Tetrahedrite.*
Biterminal. Central (c).	(*See II Uc*)	II Bc Bipyramidal. *Staurolite.*	IV Bc Ditetragonal bipyramidal. *Rutile.*	III Bc Ditrigonal scalenohedral. *Calcite.*	VI Bc Dihexagonal bipyramidal. *Beryl.*	C Bc Hexakis-octa-hedral. *Spinel.*
Contra-directional (k).	—	(*See II Bu*)	IV Bk Tetragonal scalenohedral.	—	VI Bk Ditrigonal bipyramidal.	—

A modification of the stereographic projection.

By John W. Evans, LL.B., D.Sc., F.G.S.

Imperial Institute and Birkbeck College.

[Read March 15, 1910.]

THE change suggested relates mainly to the representation of the faces below the plane of projection. I propose that every face below that plane shall be represented by the same point as a parallel face above it.

If the two parallel faces are equivalent they will both be indicated by the same circular dot (accompanied, if desired, by the indices of either face). If they are not equivalent and only one be present, it will be represented by a plus sign (+) if it be above the plane of projection, and by a minus sign with a dot in the centre (⊖) if below it. If both are present but not equivalent, the double sign (±) will be used.[1]

Under the present system parallel faces are represented by points on opposite sides of the centre and at equal distance from it, while faces symmetrically related to the plane of projection are represented by the same point. The former are of course more nearly related. Again, according to the present method the choice of the plane of projection determines whether any pair of faces are represented by one point; but if my proposal is adopted, the pairs of faces which are represented by the same points will be independent of the plane of projection.

The rationale of the new method will be at once understood when it is remembered that the stereographic representation of a face is really that of a line normal to it. If the two opposite parallel faces are equivalent the line is biterminal, the two opposite directions being equivalent. In other cases it is uniterminal, and the direction from the inside of the face to the outside may be considered as positive, and the reverse direction as negative.

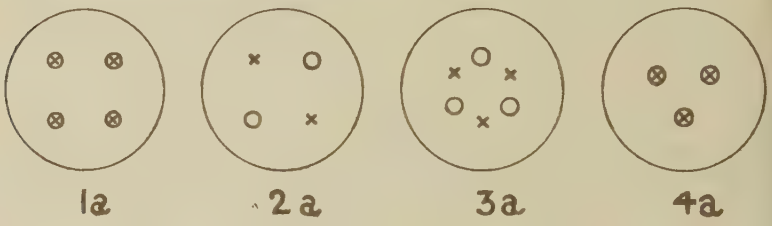
Faces at right angles to the plane of projection will obviously be

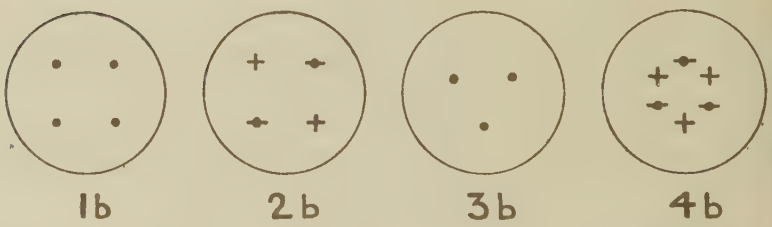
[1] The suggestion of the dot in the centre of the minus sign to represent the exact position of the point is due to Mr. H. Hilton. This will be indicated by the point of crossing of the + where that symbol is used either alone or in conjunction with the minus sign.

represented by two points. If opposite parallel faces are equivalent, each point will represent both faces. If they are not equivalent and only one be present, the positive sign will be placed on the side on which the face occurs and the negative on the other; if both are present each point will have a double sign.

On the reading of this paper Dr. Herbert Smith stated that he had found it convenient to use a similar system in recording his results when working with the three-circle goniometer.

The illustrations represent crystals belonging to the spinel, tetrahedrite, calcite, and benitoite classes:—1a, 2a, 3a, and 4a according to ordinary stereographic projection, and 1b, 2b, 3b, and 4b according to the proposed modification.





Octahedron. Tetrahedron. Rhombohedron of calcite. Trigonal bipyramid of benitoite.

On a group of minerals formed by the combustion of pyritous shales in Midlothian.

By S. J. Shand, B.Sc., Ph.D.

The Royal Scottish Museum.

[Read January 25, 1910.]

At the Emily coal pit, Arniston, Midlothian, a heap of shaly refuse from the workings became spontaneously ignited some time ago, the cause being presumably the evolution of heat by atmospheric oxidation of iron-pyrites. As a result of the slow combustion of the shale, accompanied as it is by liberation of sulphuric vapours, a number of uncommon mineral-species have been formed and deposited as sublimates in the cooler parts of the heap. The credit of discovering these minerals and recognizing their unusual character belongs to Mr. A. Craig Christie, F.L.S., from whom the specimens in the Royal Scottish Museum were obtained.

So far, five species have been distinguished, of which one may be doubtfully described as new, while three are new to Scotland. These five are the following:—

Native sulphur
Ammonium chloride (sal-ammoniac)
? Ammonia-alum (tschermigite)
Ammonium sulphate (mascagnite)
Aluminium sulphate (? new species).

Sulphur appears as a powdery encrustation and also in minute crystals which do not exceed one-tenth of a millimetre in greatest diameter. The commonest form is the simple pyramid $p\{111\}$, many crystals of this form lying on their sides in parallel position and often joined together in stacks. The combination pc (111 , 001) is also commonly seen, while either $n\{011\}$ or $e\{101\}$ may be present in addition. The pyramid-faces almost invariably show triangular pittings and depressions or 'sunk panels'.

Ammonium chloride occurs in fibrous crusts, much less commonly in crystals. The latter are either simple rhombic-dodecahedra or complete

penetration twins of two dodecahedra with *o* (111) as twin-plane (fig. 2). In the former case they are usually elongated along a trigonal axis (fig. 1). The largest crystals measure only about one millimetre in diameter. Groth,[1] and more recently Goldschmidt and Schröder,[2] have described a similar occurrence of sal-ammoniac in the burning dump of a coal pit at Burgk, Dresden. The crystals from that locality, however, are generally rough and skeletal, while the Arniston crystals are well

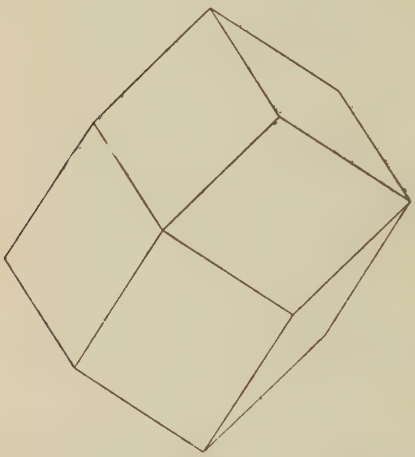


Fig. 1.

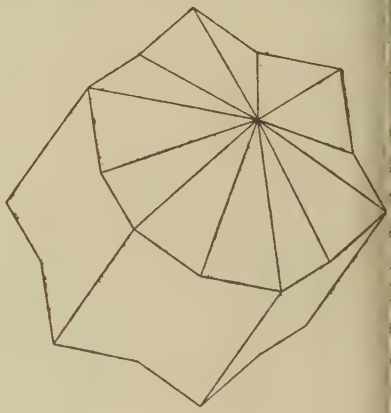


Fig. 2.

Crystals of Sal-ammoniac from Arniston, Midlothian.

developed and highly lustrous. Vesuvian crystals of the same mineral show rather complex combinations.[3] Greg and Lettsom[4] record the occurrence of sal-ammoniac 'in the vicinity of ignited coal-seams, as near Newcastle in Northumberland, and at Bradley in Staffordshire; also at Hurlet, near Paisley'.

Ammonia-alum (tschermigite) was detected by Mr. Christie by qualitative tests. I have examined all the specimens in the Museum with particular care but fail to find anything which I can refer to this species.

[1] P. Groth, 'Ueber neu gebildete Mineralproducte auf einem brennenden Steinkohlenfelde bei Dresden.' Sitzungs-Ber. naturw. Ges. Isis, Dresden, 1867, pp. 68–70.

[2] V. Goldschmidt and R. Schröder, Zeits. Kryst. Min., 1908, vol. xlv, p. 220.

[3] V. Goldschmidt and R. Schröder, loc. cit., p. 221.

[4] R. P. Greg and W. G. Lettsom, 'Manual of the Mineralogy of Great Britain and Ireland,' 1858, p. 28.

It is, however, quite probable that the alum really occurs, since the necessary ammonium and aluminium sulphates are present.

Ammonium sulphate (mascagnite) is found only in fibrous and mealy encrustations which show no peculiar characters. Greg and Lettsom[1] note the occurrence of mascagnite 'at Bradley in Staffordshire, in ignited coal-beds'.

Aluminium sulphate occurs in porous, highly vesicular masses cementing bits of cinder and burnt shale together into a kind of conglomerate. The portions which seem to be purest are quite white, but the material is more commonly stained yellow or brown by ferric sulphate. Since their arrival in the Museum the specimens have shown a tendency to deliquescence, accompanied by formation of basic iron salts and liberation of sulphuric acid. These changes make it somewhat difficult to determine the original composition of the aluminium salt. The substance in its present state contains a good deal of water, but some of this certainly is, and therefore all may be, due to deliquescence. Mr. Christie informs me that the specimens were taken by him from a part of the dump which was red-hot and in active combustion, and since the appearance of the material is that of a fused product, it seems that at the time of its removal it must have been practically anhydrous. For the purpose of analysis an undetermined weight of the cinder with adhering sulphate was treated with cold water, and all insoluble matter was filtered off and rejected. The solution was then analysed in two portions, with the results shown in the following table. Columns I and II give the actual quantities found, in grams, while column III gives the percentages of the oxides as calculated from these quantities:—

	I	II	III
Al_2O_3 ...	0·0924 ...	0·0925 ...	20·44
Fe_2O_3 ...	0·0478 ...	0·0477 ...	10·57
CaO ...	not determined ...	0·0049 ...	1·08
SO_3 ...	0·3071 ...	not determined ...	67·91
			100·00

Ammonia, magnesia, and alkalis were absent or inappreciable. By calculating the oxides into sulphates, the following proportions are obtained for the latter:—

[1] R. P. Greg and W. G. Lettsom, loc. cit., p. 70.

$Al_2(SO_4)_3$	...	68·13
$Fe_2(SO_4)_3$	...	26·28
$CaSO_4$	...	2·62
H_2SO_4	...	2·97
		100·00

The presence of the above excess of acid over bases makes it practically certain that the aluminium is present in the form of the normal sulphate; this view is supported by the solubility of the material, most basic salts of aluminium and iron being insoluble in water. Of the known sulphates of aluminium, alunogen, halotrichite, aluminite, felsöbanyite, and paraluminite are hydrous sulphates containing from nine to twenty-four molecules of water of crystallization, while aluminite, felsöbanyite, and alumian are basic salts and are insoluble in water. On the whole, the composition indicated above seems to have its nearest parallel in that of halotrichite, and it is suggested that the substance may have originated as a 'berg-butter' or impure halotrichite, that it was subsequently dehydrated by heat, and that it is now returning by absorption of moisture to its former condition. If this suggestion is correct, the pure, white substance, in its dehydrated condition as anhydrous aluminium sulphate, would represent a new mineral-species.

In conclusion, I wish to anticipate an objection that may be raised to the inclusion of these substances among minerals. It is true that the shale heap in which they originated is an artificial creation. Since, however, the materials of which the heap is composed are entirely natural, and the combustion has from the first been spontaneous, it is obvious that the process might be paralleled at any place where pyritous and carbonaceous shales are exposed to atmospheric oxidation (e.g. the 'burning cliffs' of Lyme Regis, Charmouth, &c.; see Geol. Mag., 1908, pp. 561–563). In this respect these substances have certainly a more solid claim to recognition as minerals than the laurionite and other minerals of Laurion, Greece, which have been formed from a purely artificial lead-slag. As the latter are accepted and described by all writers on mineralogy, I see no reason for refusing to recognize as minerals the substances which are discussed in the foregoing pages.

On Datolite from the Lizard district, Cornwall.[1]

By W. F. P. McLintock, B.Sc.

Assistant Curator, Museum of Practical Geology, London.

[Read March 7, 1910.]

In the course of his official work in the Lizard district, Dr. J. S. Flett collected various samples of minerals which were handed over to me for examination. Two of these specimens proved to be datolite remarkably well crystallized. As this species, now rare in Britain, had not been recorded before from Cornwall, although pseudomorphs of chalcedony after it—the well-known haytorite—are mentioned by Greg and Lettsom[2] from North Roskear mine, Camborne, the facts of its occurrence seemed well worthy of further investigation. Accordingly, in October of last year, Dr. Flett and myself paid a visit to the locality, where we succeeded in obtaining a large amount of the material.

The spot is situated in the parish of Mullion, about 550 yards SSW. of Predannack Farm in a little cove—Parc Bean Cove—lying at the foot of the cliffs. The rocks carrying the datolite are covered at high water, which renders the work of obtaining specimens somewhat awkward, and possible only at certain states of the tide; but, to compensate for this, the material is plentiful, and beautifully crystallized specimens are by no means rare. The following is Dr. Flett's description of the geology of this locality:—

'On its western margin the serpentine of the Lizard is folded with the hornblende-schist in a remarkable manner first described by Mr. Howard Fox and Dr. J. J. H. Teall.[3] The border of the main serpentine is situated about 400 yards south-east of Parc Bean Cove (at Pol Cornick), but smaller masses of serpentine are brought up among the hornblende-schists by folding at Parc Bean Cove and to the west of it. The datolite occurs at the junction of the serpentine and schist. There is a certain amount of interbanding of the two rocks, and the matrix

[1] Communicated by permission of the Director of H.M. Geological Survey.

[2] R. P. Greg and W. G. Lettsom, 'Manual of the Mineralogy of Great Britain and Ireland,' 1858, p. 231.

[3] Howard Fox and J. J. H. Teall, 'Notes on some coast sections at the Lizard.' Quart. Journ. Geol. Soc., 1893, vol. xliv, p. 199.

of the datolite-veins is partly a foliated tremolite-serpentine, partly a tremolite-schist derived from serpentine, and partly a felspar-enstatite-rock which is passing into hornblende-schist by metamorphism. The banding and foliation of the metamorphic series has a north and south strike. These rocks are traversed by crushed dolerite dykes which are posterior to the folding, but are to some extent metamorphic, and run in a west-north-west direction. The datolite-veins are not specially connected with these dykes, and are evidently long subsequent to the metamorphism, because they show no distortion or re-crystallization by pressure.'

The veins vary in size from mere threads up to those measuring 4 cm. across, but this is exceptional, the usual width being 0·5–1 cm. They consist of white, massive, crystalline datolite, and swell out every now and then into geodes lined with large, well-formed crystals. Some of these cavities attain a fair size, one specimen in the Museum of Practical Geology measuring 20 cm. in length and 5 cm. in breadth; it is covered with large crystals of white, brownish, and greenish tinges.

The material of the geodes frequently shows evidence of two stages of crystallization: (*a*) a layer of crystalline or poorly crystallized datolite, sometimes of light-brown colour and measuring 2–3 mm. in thickness; and (*b*) the large crystals mentioned above, which frequently measure 1–2 cm. along their greatest length (the *b*-axis), and which rest on the layer (*a*). They are sometimes white, but often exhibit a brownish and, more rarely, a greenish colour, and are seldom transparent, being flawed and fissured in the interior, besides enclosing little specks of copper-pyrites. At the contact of the crust with the matrix there can often be seen with a lens, and sometimes with the unaided eye, a layer of little spherules showing a fibrous-radiating structure; these consist of the botryoidal form of datolite to which the name 'botryolite' has been applied, although the material mentioned here differs optically from that found at Arendal, Norway, the original locality.

Other geodes show no evidence of two growths of datolite, there being simply a crust of white crystals with or without botryolite resting on the parent-rock. In such cases the crystals are generally smaller than when two growths are present; but there are exceptions to this, and exceedingly small crystals have been noted in the second generation.

Throughout the veins there are also smaller cavities lined with very clear, brilliant crystals, which are usually colourless, but sometimes show a pronounced green; they are associated with botryolite.

Calcite is exceedingly common on all these specimens, and is usually of

a wine-yellow colour. It occurs as simple acute rhombohedra, $f(02\bar{2}1)$, seated on the datolite, and one such crystal, showing rough, dull faces, measured 3·6 cm. along the principal axis. It is sometimes present as a brownish skin coating the datolite, and is found throughout the veins as brown crystalline masses.

Copper-pyrites is another common associate, occurring as little specks and grains in the larger crystals and in the crystalline layer beneath them.

The most interesting mineral occurring with the datolite, however, is *natrolite*, a species rare in Cornwall, but recorded from the Coverack district of the Lizard by Mr. Harford Lowe.[1] At Parc Bean Cove it is rare, and has been noted on only two of the specimens. One of these belongs to Mr. Reynell,[2] who kindly lent it to me for examination. It shows one crop of white datolite crystals with a thick layer of botryolite; yellow calcite is also present on one or two places. The natrolite occurs as small needles growing on the crystallized datolite.

The other specimen was collected by myself, and shows needles of natrolite growing on small, brilliant crystals of datolite in intimate association with yellow calcite and botryolite.

Owing to the small amount of material available, a chemical analysis was impossible, but examination on the goniometer and under the microscope confirms the view that it is natrolite.

On the goniometer the faces of the needle-like prisms do not yield good reflections, owing to striation and irregularities. It is, however, possible to make out the presence of eight of them in the zone, and they appear to be combinations of $a(100)$, $b(010)$, $m(110)$.

Under the microscope they extinguish straight with axial plane parallel to the zone of elongation, which is positive. By breaking off fragments from the end of a prism one or two were got showing the emergence of an acute bisectrix, which was positive. The refractive index is well below that of balsam.

In the Bunsen-flame the needles fuse readily to a glass, and give a strong yellow coloration.

Crystallography of the Datolite.

The crystallography of this mineral has been the subject of much investigation and discussion, and different sets of axial ratios have been used by various observers. The axes and symbols adopted here are those

[1] H. J. Lowe, Trans. R. Geol. Soc. Cornwall, 1900, vol. xii, p. 336.

[2] This specimen has since been presented to the Museum by Mr. Reynell.

given in Dana's 'System of Mineralogy', sixth edit., 1892, namely, $a:b:c = 0{\cdot}63446:1:1{\cdot}26574$; $\beta = 89° 51\frac{1}{3}'$.

The large crystals have brilliant but irregular faces and rarely yield good reflections. The irregularities on the faces take the form of waviness and striation, features which seem to be rather common in this species. The crystals are usually quite simple in development, being combinations of $c(001)$, $a(100)$, $m(110)$, $m_x(011)$, $g(012)$, $n(111)$, $\epsilon(\bar{1}12)$, $\xi(\bar{1}02)$ (figs. 1 and 2). In some cases a and ξ are suppressed (fig. 1), whilst n is often visible as a mere trace. They measure their greatest length along the b-axis and invariably show $m(110)$ well developed. The c-pinacoid is always present as a large face striated parallel to $\epsilon(\bar{1}12)$, and this striation is often carried so far as to give the face a furrowed appearance; it renders the orientation of the crystal easy. The face ξ in these large crystals is usually corroded and dull, and ϵ often shows the same appearance, though not to the same extent.

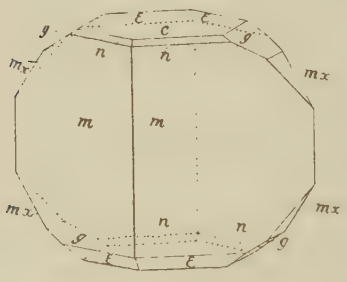


Fig. 1.

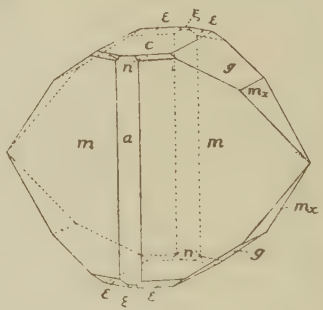


Fig. 2.

Crystals of Datolite from the Lizard district, Cornwall.

The best material for crystallographic work is found in the small crystals which line little cavities in the veins of massive datolite. They are usually bright and well modified, the faces yielding good reflections, though here again the faults mentioned above are sometimes observable. They are often attached by one end of the c-axis and are prismatic in this direction. All the forms enumerated above are present, in addition to which $x(102)$, $\lambda(\bar{1}13)$, $q(312)$, $\beta(121)$, and $\Phi(211)$ were observed. The last-named of these forms occurs as a small parallelogram yielding fair reflections and lying at the intersections of the zones [100,111] and [110,312]; it has only quite recently been described by H. Ungemach[1] as a new form on crystals of datolite from Markirch,

[1] H. Ungemach, Bull. Soc. franç. Min., 1909, vol. xxxii, p. 402.

Elsass. Single crystals occur on which all the above forms are present, and a drawing of such a combination is given (fig. 3).

On a small broken crystal a low pyramid g_o was observed lying in the zone $[ng] = [1\bar{2}1]$. It yielded an excellent reflection on the goniometer, but, unfortunately, the other faces, owing to irregularities, yielded poor readings; consequently the calculated symbol (2.15.28), is not beyond doubt. A drawing of this crystal is given (fig. 4).

On some of the smaller crystals the face m (110) is strongly striated, and on one or two individuals there appears to be another face present in this prism-zone. In such cases, however, a continuous band of images is obtained from these faces, thus rendering it impossible to determine the symbol accurately.

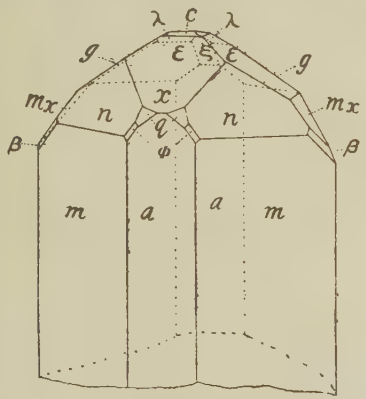


Fig. 3.

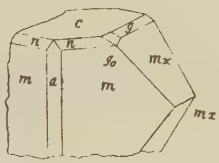


Fig. 4.

Crystals of Datolite from the Lizard district, Cornwall.

Measured and Calculated Angles.

		Measured.	Calculated.
ca	$=(001):(100)$	89° 55½′	89° 51⅓′
ax	$=(100):(102)$	44 58	45 0
xc	$=(102):(001)$	44 57	44 51
$c\xi$	$=(001):(\bar{1}02)$	44 57	45 0
mm'	$=(110):(\bar{1}10)$	115 13	115 13
gg'	$=(012):(0\bar{1}2)$	64 44	64 39
$m_x m'_x$	$=(011):(0\bar{1}1)$	103 12	103 23
cn	$=(001):(\bar{1}11)$	67 0	66 57
$c\lambda$	$=(001):(\bar{1}13)$	38 15½	38 16
$c\epsilon$	$=(001):(\bar{1}12)$	49 45	49 49
nn'	$=(111):(1\bar{1}1)$	59 4	59 4
$\lambda\lambda'$	$=(\bar{1}13):(1\bar{1}3)$	38 32	38 45
$\epsilon\epsilon'$	$=(\bar{1}12):(1\bar{1}2)$	48 10	48 19

		Measured.	Calculated.
an	$=(100):(111)$	38 50	38 55
aq	$=(100):(312)$	21 35	21 34
qq'	$=(312):(3\bar{1}2)$	22 40	22 40
$m\beta$	$=(110):(121)$	25 36	25 44
$c\Phi$	$=(001):(211)$	76 36	76 18
$a\Phi$	$=(100):(211)$	22 3½	22 2
$\Phi\Phi'$	$=(211):(2\bar{1}1)$	34 7	34 14
$m\Phi$	$=(110):(211)$	19 36	19 53
cg_o	$=(001):(2.15.28)$	34 19	34 43
ng_o	$=(111):(2.15.28)$	46 36 47 17	46 45
mg_o	$=(110):(2.15.28)$	66 26 66 52	66 40

Optical Properties.

The plane of the optic axes lies parallel to $b(010)$, and the acute and obtuse bisectrices are almost perpendicular to $a(100)$ and $c(001)$ respectively; the mineral is optically negative.

Two plates were cut, one parallel to a, the other to c, and the following values obtained on the refractometer with yellow light:—

$$\alpha = 1{\cdot}626(0),\ \beta = 1{\cdot}653(2),\ \gamma = 1{\cdot}670(2),$$

Using the faces $m(110)$ $m'(\bar{1}10)$ as a prism the following values were obtained by minimum deviation with yellow light:—

$$\beta = 1{\cdot}6530,\ \gamma = 1{\cdot}6706$$

In oil of refractive index 1·6038 the values obtained with yellow light for the axial angles were:—

$$2H_a = 76°\,58' \qquad 2H_o = 110°\,36'$$

Hence $2V_a = 74°\,16' \qquad 2V_o = 105°\,30'.$

Chemical Composition.

A quantitative analysis of the material yielded the following results:—

	Found.	Calculated for formula $HCaBSiO_5$.
SiO_2	37·45	37·6
CaO	34·67	35·0
$(Fe, Al)_2O_3$	0·57	—
B_2O_3	21·87	21·8
H_2O	5·67	5·6
Total	100·23	100·0

The powdered mineral (1·0028 gram) was evaporated repeatedly to dryness with hydrochloric acid and methyl alcohol, and the silica filtered off and determined in the usual way. From the filtrate the iron and alumina were precipitated by ammonia, filtered, ignited, and weighed together. The lime was precipitated as oxalate, ignited, and weighed as oxide, then converted into sulphate and estimated as such. The boron and water were each estimated on separated portions.

The powdered mineral (1·0085 gram) was fused with sodium carbonate and the melt treated with water and filtered. The filtrate was distilled with acetic acid and methyl alcohol into a weighed quantity of lime, and

the boron estimated from the gain in weight. The water was estimated by Penfield's method.

Specific Gravity. A determination on 0·8666 gram of the powder used in the above analysis gave, with the pycnometer, the value 3·001 at 14° C.

Botryolite.

This variety occurs as a layer between the matrix and the crystallized crusts. It sometimes forms fairly large masses intermingled with the crystalline material of the veins; occasionally it is stained a pronounced green on the surface.

The botryolite found here differs from that described by Lacroix[1] from Arendal, Norway. The material from that locality shows, under the microscope, fibres which extinguish straight, and yield sometimes a positive, obtuse bisectrix, sometimes a negative, acute bisectrix, the axial plane being perpendicular to the zone of elongation. Consequently these fibres are elongated parallel to the edge [100,001], i. e. the *b*-axis.

When the Cornish botryolite is crushed and examined under the microscope certain of the fibres extinguish straight, and, with convergent light, the axial plane is seen to be parallel to the zone of elongation and the bisectrix obtuse and positive. They are therefore elongated parallel to the *a*-axis.

A large number of the fibres, however, do not extinguish straight but at from 30° to 40° to the zone of elongation. They frequently show the emergence of an obtuse, positive bisectrix, and appear to be elongated in some direction lying in the plane *c*(001).

On one or two specimens there occurs in small quantity a brownish, amorphous mineral filling up the interstices between the small crystals. Owing to lack of material I was unable to identify it, but it may possibly be a variety of datolite similar to that from Lake Superior.

Until the discovery of the locality described above, datolite has been a mineral of rare occurrence in England, and indeed in the British Islands. The best known localities, hitherto, have been in Scotland, but specimens of late have become very scarce. The crystals on the Scottish specimens are usually small, although Heddle[2] records some from Salisbury Crags, Edinburgh, which measured $\frac{3}{4}$ inch in length.

[1] A. Lacroix, Bull. Soc. Min. de France, 1885, vol. viii, p. 433.
[2] M. F. Heddle, 'Mineralogy of Scotland,' 1901, vol. ii, p. 63.

In England Busz[1] has recorded datolite with garnet in the limestone of South Brent, Devonshire, but only in small quantity.

It is thus satisfactory that a good locality for this mineral has been found, and that another name should be added to the long list of minerals found in Cornwall.

In conclusion, I wish to express my thanks to Dr. J. S. Flett for the interest he has taken in the investigation, and to Dr. W. Pollard for much valuable help given in the chemical part of the work.

[1] K. Busz, Neues Jahrb. Min., 1899, Beilage-Band xiii, p. 127.

A (fifth) list of new mineral names: with an index of authors.[1]

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[Communicated June 7, 1910.]

Aglaurite. R. Handmann, 1907. Zeits. Min. Geol. Stuttgart, vol. i, p. 78. Orthoclase-felspar with a fine blue reflection forming a constituent of quartz-porphyry (Aglauritporphyr) from Teplitz, Bohemia. Named from ἄγλαυρος = ἀγλαός, bright.

Alaite. K. A. Nenadkevič, 1909. Bull. Acad. Sci. Saint-Pétersbourg, ser. 6, vol. iii, p. 185 (Алаитъ). Hydrated vanadic oxide, $V_2O_5 . H_2O$, forming blood-red, mossy growths with silky lustre. Found with turanite (q. v.) in the neighbourhood of the Alai Mountains, Russian Central Asia.

Alamosite. C. Palache and H. E. Merwin, 1909. Amer. Journ. Sci., ser. 4, vol. xxvii, p. 399; Zeits. Kryst. Min., vol. xlvi, p. 513. Lead meta-silicate, $PbSiO_3$, occurring as snow-white, radially fibrous masses. Crystals are monoclinic, though apparently not isomorphous with wollastonite. From Alamos, Sonora, Mexico. Prepared artificially by S. Hilpert and P. Weiller, Ber. Deutsch. Chem. Ges., 1909, vol. xlii, p. 2969.

Aloisiite. L. Colomba, 1908. Rend. R. Accad. Lincei, Roma, ser. 5, vol. xvii, sem. 2, p. 233. A hydrated sub-silicate of calcium, ferrous iron, magnesium, sodium, and hydrogen, $(R'', R'_2)_4\ SiO_6$, occurring in an amorphous condition, intimately mixed with calcium carbonate, in a palagonite-tuff at Fort Portal, Uganda. Named in honour of H.R.H. Prince Luigi Amedeo of Savoy, Duke of Abruzzi. Aloisius or Aloysius is a Latin form of Luigi or Lewis.

[1] Previous lists of this series are given at the ends of vols. xi, xii, xiii, and xiv of this Magazine (1897, 1900, 1903, 1907). In the present list are included several trivial names which have been recently applied for trade purposes to the cheaper gem-stones. Although such names are here listed alphabetically for convenience of reference, it is to be hoped that they will not find their way into mineralogical literature.

Alomite. Trade-name for the fine blue sodalite quarried at Bancroft, Ontario, Canada, for use as an ornamental stone. Named alomite [not allomite] after Charles Allom, of White, Allom & Co., marble merchants, London. Also called 'Princess Blue'. (The Quarry, London, 1908, vol. xiii, p. 257. W. G. Renwick, 'Marble and marble working,' London, 1909, p. 115.)

Alundum. Trade-name for artificial corundum manufactured in the electric furnace from bauxite by the Norton Emery Wheel Company, of Worcester, Mass., since 1904. The material is used as an abrasive, and the name is no doubt a contraction of aluminium and carborundum (4th list). (Mineral Industry, New York, for 1906, 1907, vol. xv, p. 28.)

Amatrice. Trade-name for a green gem-stone from Utah, consisting of variscite, utahlite, or wardite, or a mixture of these, in a matrix of quartz, chalcedony, &c. So called (A-matrix) because it is an American matrix gem-stone. (D. B. Sterrett, Mineral Resources of the United States, for 1907, 1908, part ii, p. 832. J. Wodiska, A book on precious stones, New York, 1909, p. 185.)

Anemousite. H. S. Washington and F. E. Wright, 1910. Amer. Journ. Sci., ser. 4, vol. xxix, p. 61. A plagioclase-felspar found, together with linosite (q. v.), as loose crystals in a volcanic tuff on the Island of Linosa, off the coast of Tunis. The silica percentage is rather lower than that required by the albite-anorthite series, and the composition is explained as a mixture of albite and anorthite together with soda-anorthite (carnegieite, q. v.) in the ratio 8 : 10 : 1. Named from the ancient Greek name of the island.

Anophorite. W. Freudenberg, 1908. Mitt. Badisch. geol. Landesanst., 1908, vol. vi, p. 45 (Anophorit). A variety of alkali-hornblende from the shonkinite of the Katzenbuckel, Baden. It resembles catophorite in its pleochroism, but differs in chemical composition (containing more MgO and less FeO) and optical orientation. Named from *ἀνώφορος*, ascending, because the angle of optical extinction is less than that of catophorite.

Arizonite. C. Palmer, 1909. Amer. Journ. Sci., ser. 4, vol. xxviii, p. 353. Ferric meta-titanate, $Fe_2O_3 . 3TiO_2$, found as irregular masses, with sub-conchoidal fracture, dark steel-grey colour, and metallic to sub-metallic lustre, in a pegmatite-vein near Hackberry in Arizona. It is probably monoclinic, and is distinct from ilmenite (ferrous titanate, $FeO . TiO_2$).

Asphaltite. W. P. Blake, 1890. Trans. Amer. Inst. Mining Engin., vol. xviii, p. 576. G. H. Eldridge, 22nd Ann. Rep. United States Geol. Survey, for 1900–1, 1901, part i, p. 220. The same as asphalt or asphaltum with the mineralogical termination *ite*. Includes the solid bituminous hydrocarbons known as albertite, impsonite (q. v.), gilsonite, grahamite, nigrite, and uintahite. The word asphaltite appears in Greek and in English dictionaries as an adjective, meaning bituminous or asphaltic.

Azurchalcedony. G. F. Kunz, 1907. *See* Azurlite.

Azurlite or Azurchalcedony. G. F. Kunz, 1907. [New York Acad. Sci., April, 1907] quoted in Mineral Industry, New York, for 1907, 1908, vol. xvi, p. 792. Chalcedony coloured blue by chrysocolla, from Arizona; used as a gem-stone.

Azurmalachite. G. F. Kunz, 1907. Engin. and Mining Journ. New York, vol. lxxxiv, p. 296; Mineral Industry, New York, for 1907, 1908, vol. xvi, p. 792. D. B. Sterrett, Mineral Resources of the United States, for 1907, 1908, part ii, p. 797; for 1908, 1909, part ii, p. 809. A popular term for a mixture of azurite and malachite in concentric bands; used as a gem-stone. From Arizona.

Beldongrite. L. L. Fermor, 1909. Mem. Geol. Survey India, vol. xxxvii, pp. lxix, 115. A black, pitch-like mineral closely allied to psilomelane. Formula, perhaps $6Mn_3O_5 . Fe_2O_3 . 8H_2O$. Probably an alteration product of spessartite. From Beldongri, Nágpur district, Central Provinces, India.

Benitoite. G. D. Louderback, 1907. Bull. Dep. Geol. Univ. California, vol. v, p. 149; ibid., 1909, vol. v, p. 331. Also papers and notes by R. Arnold, H. Baumhauer, W. C. Blasdale, C. Hlawatsch, F. H. Kraus, C. Palache, and A. F. Rogers, references to which are given in Louderback's later paper. B. Ježek, Bull. Intern. Acad. Sci. Bohême, 1909, année xiv, p. 213.

An acid titano-silicate of barium $BaTiSi_3O_9$, forming beautiful, sapphire-blue, transparent crystals, suitable for cutting as gems, and the only representative (except Ag_2HPO_4, H. Dufet, 1886) of the ditrigonal-bipyramidal class of the hexagonal system. Occurs with neptunite in natrolite veins traversing schistose rocks near the source of the San Benito River, in San Benito Co., California.

Bityite. A. Lacroix, 1908. Compt. Rend. Acad. Sci. Paris, vol. cxlvi, p. 1371; Bull. Soc. franç. Min., vol. xxxi, p. 241. Small,

yellowish-white, pseudo-hexagonal prisms occurring with tourmaline in pegmatite near Mt. Bity [or Ibity] in Madagascar. A basic orthosilicate, $10SiO_2 . 8Al_2O_3 . 5\frac{1}{2}(Ca,Be,Mg)O . 1\frac{1}{2}(Li,Na,K)_2O . 7H_2O$, allied to staurolite.

Bonamite. A jeweller's trade-name for an apple-green calamine ($ZnCO_3$), resembling chrysoprase in colour, from Kelly, New Mexico. Called 'bonamite' by Goodfriend Brothers, of New York [no doubt in playful allusion to their own name]. (D. B. Sterrett, Mineral Resources of the United States, for 1908, 1909, part ii, p. 839.)

Bravoite. W. F. Hillebrand, 1907. Amer. Journ. Sci., ser. 4, vol. xxiv, p. 151; Journ. Amer. Chem. Soc., vol. xxix, p. 1028. D. F. Hewett, Trans. Amer. Min. Engin., 1910, vol. xl, p. 286. A highly nickeliferous (Ni,18 per cent.) pyrites, $(Fe,Ni)S_2$, disseminated as grains in vanadium-ore (patronite) from Minasragra, near Cerro de Pasco, Peru. Named after José J. Bravo, of Lima, Peru.

Brugnatellite. E. Artini, 1909. Rend. R. Accad. Lincei, Roma, ser. 5, vol. xviii, sem. 1, p. 3; Riv. Min. Crist. Italiana, xxxvii, p. 119. A hydrated ultra-basic carbonate

$$Mg_6FeCO_{20}H_{21} = MgCO_3 . 5Mg(OH)_2 . Fe(OH)_3 . 4H_2O.$$

Flesh-red, lamellar masses with perfect micaceous cleavage. Optically uniaxial; rhombohedral or hexagonal. Found in an asbestos quarry in Val Malenco, Lombardy. Named after Dr. Luigi Brugnatelli, professor of mineralogy in the University of Pavia.

Calciopalygorskite. A. Fersmann, 1908. Bull. Acad. Sci. Saint-Pétersbourg, ser. 6, vol. ii, p. 274 (Calciopalygorskit). A 'mountain-leather' from Strontian, Argyllshire, containing much calcium (CaO, 10 per cent., according to T. Thomson's analysis, 1836).

Carlosite. G. D. Louderback, 1907. Bull. Dep. Geol. Univ. California, vol. v, p. 153; ibid., 1909, vol. v, p. 354. A supposed new mineral, found with benitoite (q. v.) in San Benito Co., California, which was very soon afterwards identified with the neptunite of Greenland. Named from the San Carlos peak, one of the highest points in the locality.

Carnegieite. H. S. Washington and F. E. Wright, 1910. Amer. Journ. Sci., ser. 4, vol. xxix, p. 52. A triclinic felspar closely allied to the plagioclases, which from its composition, $Na_2Al_2Si_2O_8$, may be described as soda-anorthite (S. J. Thugutt, 1895; 2nd list), sodium taking the place of calcium in the anorthite formula. It has been

prepared artificially; and, in isomorphous intermixture with albite and anorthite, its presence is assumed to explain the composition of anemousite (q. v.). Named after Andrew Carnegie, founder of the Carnegie Institution of Washington, D.C., where the mineral was determined.

The compound $Na_2Al_2Si_2O_8$ is dimorphous, being also prepared artificially as hexagonal crystals closely allied to nepheline.

Chapapote. *See* Malthite.

Chromitite. M. Z. Jovitschitsch, 1908. Sitzungsber. Akad. Wiss. Wien, Math.-naturwiss. Klasse, vol. cxvii, Abt. II b, p. 818; Monatshefte für Chemie, &c., Wien, 1909, vol. xxx, p. 44 (Chromitit). Oxide of chromium and iron, $FeCrO_3 = Fe_2O_3 . Cr_2O_3$, found as shining octahedra in the sands of streams from the Kopaonik Mountains, Servia. Differs from chromite in containing ferric oxide in place of ferrous oxide [and therefore possibly an altered chromite].

Clayite. J. W. Mellor, 1909. Trans. English Ceramic Soc., Longton, vol. viii, p. 28. The non-crystalline variety of kaolinite, $Al_2O_3 . 2SiO_2 . 2H_2O$, of which china-clay and most other clays are largely composed. Not the clayite of W. J. Taylor, 1859.

Clinobronzite. W. Wahl, 1906. *See* Clinoenstatite. W. Wahl, loc. cit. (Klinobronzit). A. Lacroix, loc. cit. (Clinobronzite).

Clinoenstatite. W. Wahl, 1906. Die Enstatitaugite, Helsingfors, May 1906, p. 141; Min. Petr. Mitt. (Tschermak), 1907, vol. xxvi, p. 121; Öfvers. Finska Vet. Soc. Förh., 1908, vol. l, No. 2, p. 1 (Klinoenstatit). A. Lacroix, Bull. Soc. Sci. Nat. Ouest France, September 1906, ser. 2, vol. vi, p. 94 (Clinoenstatite). E. T. Allen and others, Amer. Journ. Sci., 1909, ser. 4, vol. xxvii, pp. 30, 45 (clino-enstatite). F. Zambonini, Zeits. Kryst. Min., 1909, vol. xlvi, pp. 12, 601. F. E. Wright, Zeits. Kryst. Min., 1909, vol. xlvi, p. 599.

A monoclinic pyroxene with the chemical composition of enstatite; that is, dimorphous with enstatite, and differing from diopside in containing no calcium. It occurs in meteoric stones, and has been prepared artificially (β-$MgSiO_3$). The magnesium-diopside of H. Rosenbusch (1905; 4th list) approximates to this.

Similarly, clinobronzite and clinohypersthene are dimorphous forms of the magnesium-iron meta-silicates bronzite and hypersthene respectively.

Clinohypersthene. W. Wahl, 1906. *See* Clinoenstatite. W. Wahl, loc. cit. (Klinohypersthen). A. Lacroix, loc. cit., p. 93 (Clinohypersthène).

Cobaltocalcite. F. Millosevich, 1910. Rend. R. Accad. Lincei, Roma, ser. 5, vol. xix, sem. 1, p. 92. A bright red variety of calcite containing cobalt (CoO, 1·27 per cent.), occurring as crystalline masses at Capo Calamita, Elba.

Colomite. J. Blake, 1876. Proc. California Acad. Sci., vol. vi (for 1875), p. 150. A supposed chromium mica, from Coloma, California, which was re-described by the author in the same year under the name of roscoelite or vanadium mica.

Delorenzite. F. Zambonini, 1908. Rend. R. Accad. Sci. Fis. Mat. Napoli, ser. 3, vol. xiv, p. 113; Riv. Min. Crist. Italiana, vol. xxxiv, p. 74; Zeits. Kryst. Min., vol. xlv, p. 76. Black, orthorhombic crystals resembling polycrase (but differing from this in containing no niobium), from pegmatite at Craveggia, Piedmont. $2FeO . UO_2 . 2Y_2O_3 . 24TiO_2$, or expressed as a meta-titanate

$$2FeTiO_3 . U(TiO_3)_2 . 2Y_2(TiO_3)_3 . 7(TiO)TiO_3.$$

Named after Giuseppe De Lorenzo, professor of geology in the University of Naples.

Didjumolite. *See* Didymolite.

Didymolite. A. Meister, 1908. Verh. Russ. Mineral. Ges., ser. 2, vol. xlvi, p. 151 (Дидюмолить). Monoclinic, twinned crystals in nepheline-syenite from Siberia. $2CaO . 3Al_2O_3 . 9SiO_2$. Named from *δίδυμος*, a twin, and *λίθος*, a stone. The German translation of the title on the wrapper of the journal gives the form Didjumolit.

Ehrenwerthite. F. Cornu, 1909. Zeits. prakt. Geol., Jahrg. xvii, p. 82 (Ehrenwerthit). Colloidal hydroxide of iron with the same composition ($Fe_2O_3 . H_2O$) as the crystalline mineral goethite; occurring as pseudomorphs after iron-pyrites. Named after Professor Josef von Ehrenwerth, of Leoben, Styria.

Enstatite-augite. W. Wahl, 1906. Die Enstatitaugite, Helsingfors, 1906; Min. Petr. Mitt. (Tschermak), 1907, vol. xxvi, p. 1; Öfvers. Finska Vet. Soc. Förh., 1908, vol. l, No. 2, p. 11. A group of monoclinic pyroxenes intermediate in optical properties and chemical composition between the enstatite group and the calcium-bearing monoclinic pyroxenes (diopside, augite, &c.), and yet distinct from clinoenstatite (q. v.). For the various members of the group several compound names are given, e. g. enstatite-diopside, bronzite-augite, augite-bronzite, hypersthene-hedenburgite, &c.

Ferganite. I. A. Antipov, 1908. Gornyi Zhurnal, St. Petersburg, year lxxxiv, vol. iv, p. 259 (Ферганитъ); abstract in Neues Jahrb. Min., 1909, vol. ii, Ref. p. 38 (Ferghanit). A hydrated uranium vanadate, $U_3(VO_4)_2 . 6H_2O$, containing also a small amount of lithium. Found as sulphur-yellow scales, together with other uranium minerals, in province Fergana, Russian Turkistan. Related to carnotite.

Fermorite. G. T. Prior and G. F. H. Smith, 1910. Nature, London, vol. lxxxiii, p. 513. Arsenate, phosphate, and fluoride of calcium and strontium, isomorphous with apatite. Occurs as white, crystalline masses in the Indian manganese-ore deposits. Named after Dr. Lewis Leigh Fermor, of the Geological Survey of India.

Ferripurpurite. W. T. Schaller, 1907. Amer. Journ Sci., ser. 4, vol. xxiv, p. 154. Purpurite (L. C. Graton and W. T. Schaller, 1905; 4th list, 1907) is a hydrated manganic ferric phosphate, $2(Mn,Fe)PO_4 . H_2O$, in which either manganese or iron may predominate. For the end members of this isomorphous series the names ferripurpurite and manganipurpurite are suggested.

Ferroaxinite. W. T. Schaller, 1909. Second Appendix to 6th edit. of Dana's System of Mineralogy, p. 11. Axinite consists of isomorphous mixtures of ferroaxinite, $8SiO_2 . 2Al_2O_3 . 2FeO . H_2O . 4CaO . B_2O_3$, and manganoaxinite, $8SiO_2 . 2Al_2O_3 . 2MnO . H_2O . 4CaO . B_2O_3$.

Georgiadesite. A. Lacroix and A. de Schulten, 1907. Compt. Rend. Acad. Sci. Paris, vol. cxlv, p. 784; Bull. Soc. franç. Min., 1908, vol. xxxi, p. 86 (georgiadésite). White or brownish-yellow, orthorhombic crystals associated with lead oxychlorides in the ancient lead slags at Laurion, Greece. A chloro-arsenate of lead, $Pb_3(AsO_4)_2 . 3PbCl_2$, containing much more chlorine than mimetite. Named after Mr. — Georgiades, director of the mines at Laurion.

Grandite. L. L. Fermor, 1909. Mem. Geol. Survey India, vol. xxxvii, pp. lxxi, 165. A contraction from grossularite and andradite for garnets of intermediate composition. A manganiferous variety is called 'mangan-grandite'. Compare 'spandite' (L. L. Fermor, 1907; 4th list).

Hallerite. P. Barbier, 1908. Compt. Rend. Acad. Sci. Paris, vol. cxlvi, p. 1221 (Hallérite). A lithium-bearing variety of soda-mica (paragonite) resembling muscovite in appearance. From Mesvres, Autun, France. Named after Albin Haller, professor of organic chemistry at the Sorbonne, Paris.

Hampdenite. A. D. Roe, 1906. Bull. Minnesota Acad. Sci., vol. iv, p. 268. A variety of serpentine from Hampden Co., Massachusetts; it forms the matrix of the pseudomorphs of serpentine after olivine known as hampshirite. C. Palache (Amer. Journ. Sci., 1907, ser. 4, vol. xxiv, p. 494) points out that it does not differ from picrolite.

Hawaiite. C. Elschner, 1906. Chemiker-Zeitung, Jahrg. xxx, p. 1119 (Hawaiit). A gem-variety of olivine from the lavas of the Hawaiian Islands. It contains but little iron, and is pale green in colour.

Hillebrandite. F. E. Wright, 1908. Amer. Journ. Sci., ser. 4, vol. xxvi, p. 551. J. E. Spurr and G. H. Garrey, Economic Geology, 1908, vol. iii, p. 707. Hydrated calcium ortho-silicate, $Ca_2SiO_4 . H_2O$. A white, porcellanous mineral with fibrous structure and orthorhombic symmetry. Occurs with spurrite (q. v.) in contact-metamorphic limestone at Velardeña, Durango, Mexico. Named after Dr. William Francis Hillebrand, of Washington, D.C.

Howdenite. Amer. Journ. Sci., 1907, ser. 4, vol. xxiv, p. 184. A local name for the large crystals of chiastolite found by G. R. Howden at Mount Howden, near Bimbowrie, South Australia, and described by C. Anderson (Records Australian Museum, 1902, vol. iv, p. 298).

Hulsite. A. Knopf and W. T. Schaller, 1908. Amer. Journ. Sci., ser. 4, vol. xxv, p. 323. W. T. Schaller, in 2nd Appendix to Dana's System of Mineralogy, 1909, p. 53; Amer. Journ. Sci., 1910, ser. 4, vol. xxix, p. 543. A. Knopf and W. T. Schaller, Zeits. Kryst. Min., 1910, vol. xlviii, p. 1. A black, opaque, orthorhombic (?) mineral occurring in a contact-metamorphic limestone in connexion with the tin-ores of Alaska. Originally described as a hydrous borate of ferrous and ferric iron and magnesium, but subsequently found to contain some tin. The revised formula is

$$12(Fe,Mg)O . 2Fe_2O_3 . SnO_2 . 3B_2O_3 . 2H_2O.$$

Named after Alfred Hulse Brooks, of the United States Geological Survey. *See* Pageite.

Hydrothomsonite. K. D. Glinka, 1906. Trav. Soc. Nat. Saint-Pétersbourg, vol. xxxiv, Sect. Géol. Min., p. 61 (Гидротомсонить), p. 176 (Hydrothomsonit). A zeolite, $(H_2,Na_2,Ca)Al_2Si_2O_8 . 5H_2O$, differing from thomsonite in containing more water (29·8 per cent.). Small, white or colourless, prismatic crystals with straight optical extinction. Occurs in soil as a product of weathering of augite-andesite in Transcaucasia.

Impsonite. G. H. Eldridge, 1901. 22nd Ann. Rep. United States Geol. Survey, 1900–1, part i, p. 265. Described by J. A. Taff (Amer. Journ. Sci., 1899, ser. 4, vol. viii, p. 219) as an albertite-like asphaltum occurring in the Choctaw Nation, Indian Territory: Impson Valley is one of the localities mentioned. It differs from albertite in being almost insoluble in turpentine.

Isomicrocline. W. Luczizky, 1905. Min. Petr. Mitt. (Tschermak), vol. xxiv, p. 347 (Isomikroklin). An optically positive microcline, analogous to the isorthose of L. Duparc, 1904 (4th list).

Jadeolite. G. F. Kunz, 1908. Mineral Industry, New York, for 1907, vol. xvi, p. 810. A deep-green chromiferous syenite cut as a gem-stone and resembling jade in appearance; from the jadeite mine at Bhamo, Burma. Possibly the same as the pseudojadeite (q. v.) of A. W. G. Bleeck, 1908.

Joaquinite. G. D. Louderback, 1909. Bull. Dep. Geol. Univ. California, vol. v, p. 376. Honey-yellow, orthorhombic crystals found associated with benitoite (q. v.): they contain silicon, titanium, calcium, and some iron, but have not yet been completely determined. Named from the Joaquin ridge of the Diablo range, San Benito Co., California.

Jordisite. F. Cornu, 1909. Zeits. Chem. Indust. Kolloide, vol. iv, p. 190 (Jordisit). A black, powdery, colloidal form of molybdenum sulphide, considered to be distinct from the crystalline mineral molybdenite. It occurs in the Himmelsfürst mine, Freiberg, Saxony, and alters to ilsemannite.

Juddite. L. L. Fermor, 1908. Rec. Geol. Survey India, vol. xxxvii, p. 211; Mem. Geol. Survey India, 1909, vol. xxxvii, pp. lxxi, 159. A manganiferous amphibole associated with the manganiferous pyroxene blanfordite (L. L. Fermor, 1906; 4th list) in a braunite-albite rock at Kácharwáhi, Nágpur district, Central Provinces, India. The pleochroism (carmine, blue or green, and orange) is intense, and the optic axial plane is perpendicular to the plane of symmetry. Named after Professor John Wesley Judd, of London.

Karystiolite. J. W. Evans, 1909. Geol. Mag., dec. 5, vol. vi, p. 286. Compare Mineralogical Magazine, 1906, vol. xiv, p. 143. A modernized form of *καρύστιος λίθος* (Karystian stone), a mineral, identified with chrysotile, from Karystos in Euboea. Suggested as an alternative for chrysotile, owing to the confusion between this name and the name chrysolite.

Kliachite. F. Cornu, 1909. Zeits. Chem. Indust. Kolloide, vol. iv, p. 90 (Kliachit). Colloidal aluminium hydroxides, α-kliachite. $Al_2O_3 . H_2O$, and β-kliachite, $Al_2O_3 . 3H_2O$, forming, together with iron hydroxides and the crystalloids diaspore ($Al_2O_3 . H_2O$) and hydrargillite ($Al_2O_3 . 3H_2O$), the constituent minerals of bauxite.

Klinobronzit. W. Wahl, 1906. *See* Clinobronzite.

Klinoenstatit. W. Wahl, 1906. *See* Clinoenstatite.

Klinohypersthen. W. Wahl, 1906. *See* Clinohypersthene.

Leesbergite. L. Blum, 1908. Ann. Soc. géol. Belgique, vol. xxxiv, Bull. p. 118. W. Bruhns, Mitt. geol. Landesanst. Elsass-Lothringen, 1908, vol. vi, p. 303. A white, chalky mineral forming a vein in iron-ore (oolitic minette) near Hayingen, Lorraine, and described as a hygroscopic carbonate of calcium and magnesium $Mg_2Ca(CO_3)_3$. Proved by W. Bruhns to be a mixture of hydromagnesite with calcite or dolomite. Named in memory of the late Mining-Captain F. X. H. Leesberg, of Esch on the Alzette, Luxemburg.

Lenad. W. Cross and others, 1903. Quantitative Classification of Igneous Rocks, Chicago, 1903, pp. 132, 271. J. P. Iddings, Igneous Rocks, New York, 1909, vol. i, p. 411. A contracted form of the names leucite and nephelite, suggested as an alternative group name for the felspathoid minerals.

Linosite. H. S. Washington, 1908. Amer. Journ. Sci., ser. 4, vol. xxvi, p. 210. A highly titaniferous basaltic hornblende, closely allied to kaersutite, found with anemousite (q. v.) as loose, monoclinic crystals in a volcanic tuff on the Island of Linosa, off the coast of Tunis.

Loaisite. R. L. Codazzi, 1905. Mineralizadores y minerales metálicos de Colombia. Trabajos de la Oficina de Historia Natural, Secc. Min. Geol., Bogota, 1905, p. 16 (Loaisita). Scorodite in very pale green, porous masses, from Loaysa, near Marmato, Colombia, analysed by J. B. Boussingault in 1829.

Lublinite. N. S. Watitsch (Vatič), 1908. Ann. Géol. Min. Russie, vol. ix, p. 239 (Люблинитъ), p. 241 (Lublinit). A form of calcite occurring as a mould-like encrustation on chalk-marl in govt. Lublin, Russian Poland. It consists of a matted aggregate of capillary or acicular crystals greatly elongated in the direction of an edge of the primary rhombohedron. Giving oblique optical extinction, these crystals

had been previously described as monoclinic or triclinic, and by one author are stated to be hydrated calcium carbonate (L. L. Ivanov, ibid., 1905, vol. viii, p. 23). *See* Pentahydrocalcite and Trihydrocalcite.

Luigite. L. Colomba, 1908. Rend. R. Accad. Lincei, Roma, ser. 5, vol. xvii, sem. 2, p. 237. The same as aloisiite (q. v.), the latter name being preferred, since the Italian form luigite may be confused with Lewisite.

Magnesium-axinite. J. Fromme, 1909. Min. Petr. Mitt. (Tschermak), vol. xxviii, p. 311 (Magnesiumaxinit). A hypothetical axinite with the composition $HMgCa_2BAl_2Si_4O_{16}$.

Magnesium-pectolite. E. Reuning, 1907. Centralblatt Min., p. 739 (Magnesiumpektolith). Pectolite containing some magnesium (MgO, 5½ per cent.). Occurs in crevices in diabase at Burg, Hesse-Nassau.

Malthite. W. P. Blake, 1890. Trans. Amer. Inst. Mining Engin., vol. xviii, p. 582. The same as maltha. A group name to include the viscous bituminous hydrocarbons known as maltha, mineral tar, pitt-asphalt, brea (Spanish), chapapote (Cuban Spanish).

Manganaxinite. J. Fromme, 1909. Min. Petr. Mitt. (Tschermak), vol. xxviii, p. 311 (Manganaxinit). Axinite rich in manganese (MnO, 11·54 per cent.) from the Harz. $HMnCa_2BAl_2Si_4O_{16}$.

Mangan-grandite. L. L. Fermor, 1909. *See* Grandite.

Manganipurpurite. W. T. Schaller, 1907. *See* Ferripurpurite.

Manganoaxinite. W. T. Schaller, 1909. *See* Ferroaxinite.

Mercurammonite. W. F. Hillebrand and W. T. Schaller, 1909. Bull. United States Geol. Survey, No. 405, p. 18; Zeits. Kryst. Min., 1910, vol. xlvii, p. 444 (Merkurammonit). A name suggested by the chemical composition of the mineral previously called kleinite (A. Sachs, 1905; 4th list), but regarded by the authors as a synonym.

Metacristobalite. A. Lacroix, 1909. Minéralogie de la France, vol. iii, p. 806 (métacristobalite). The optically isotropic phase of cristobalite stable above 175° C.

Natrochalcite. C. Palache and C. H. Warren, 1908. Amer. Journ. Sci., ser. 4, vol. xxvi, p. 342; Zeits. Kryst. Min., vol. xlv, p. 534. Hydrous sulphate of copper and sodium, $Na_2SO_4 . Cu_4(OH)_2(SO_4)_3 . 2H_2O$, forming bright emerald-green, monoclinic crystals with an acute pyramidal

habit. It occurs with several other species of sulphates in copper-veins in the mining district of Chuquicamata, Antofagasta, Chile.

Natronsanidine. F. von Wolff, 1904. Centralblatt Min., 1904, p. 208 (Natronsanidin). A monoclinic felspar with the habit of sanidine, but containing much soda, the composition being $Or_1Ab_1 = K_2Na_2AlSi_3O_8$.

Nephritoid. J. Fromme, 1909. Min. Petr. Mitt. (Tschermak), vol. xxviii, p. 306. A nephrite-like mineral occurring as a vein in weathered harzburgite in the Radauthal, Harz. It is also similar to nephrite in chemical composition, but it differs, as seen under the microscope, in having the fibres parallel, instead of matted as in true nephrite; it may therefore be described as a compact actinolite.

Neslite. A. Leymerie, 1846. Statistique géologique et minéralogique du département de l'Aube, Troyes, 1846, pp. 73, 117, 669. A. Lacroix, Minéralogie de la France, 1901, vol. iii, p. 335. A variety of opal, closely resembling menilite, occurring as reniform nodules in marl at Nesle, dep. Marne.

Orthobromite. J. V. Samojlov, 1906. Materialien zur Geologie Russlands, vol. xxiii, p. 146 (Ортобромить); abstract in Neues Jahrb. Min., 1907, vol. ii, Ref. p. 194 (Orthobromid [*sic*]). A variety of embolite with the composition AgCl . AgBr, as distinct from A. Breithaupt's megabromite (4AgCl . 5AgBr), and microbromite (3AgCl . AgBr). From the Donetz Basin, South Russia.

Ostwaldite. F. Cornu, 1909. Zeits. Chem. Indust. Kolloide, vol. iv, p. 187 (Ostwaldit). The colloidal (hydrogel) form of silver chloride obtained by precipitation, and represented in nature by 'buttermilk silver', cerargyrite being the crystalloidal form. Named after Professor Wilhelm Ostwald, of Leipzig.

Oxykertschenite. S. P. Popov, 1907. Bull. Acad. Sci. Saint-Pétersbourg, ser. 6, vol. i, p. 138 (Оксикерченить). Hydrated ferric phosphate with small amounts of manganese, &c.,

$$(Mn,Mg,Ca)O . 4Fe_2O_3 . 3P_2O_5 . 21H_2O.$$

Occurs as a brown alteration product of paravivianite and kertschenite (S. P. Popov, 1906; 4th list) in the Kerch (German, Kertsch) peninsula, Crimea.

Paigeite. A. Knopf and W. T. Schaller, 1908. Amer. Journ. Sci., ser. 4, vol. xxv, p. 324. W. T. Schaller, in 2nd Appendix to Dana's System of Mineralogy, 1909, p. 78; Amer. Journ. Sci., 1910, ser. 4,

vol. xxix, p. 543. A. Knopf and W. T. Schaller, Zeits. Kryst. Min., 1910, vol. xlviii, p. 1. A coal-black, lustrous and opaque aggregate of matted fibres and long needles, with a foliated appearance, occurring in a contact-metamorphic limestone in connexion with the tin-ores of Alaska. Originally described as a hydrous borate of ferrous and ferric iron, but subsequently found to contain a considerable amount of tin, the probable formula being $30FeO \cdot 5Fe_2O_3 \cdot SnO_2 \cdot 6B_2O_3 \cdot 5H_2O$. It is suggested, however, that the mineral may possibly be a mixture of hulsite (q. v.) and an iron borate. Named after Sidney Paige, of the United States Geological Survey.

Parahopeite. L. J. Spencer, 1907. Nature, London, vol. lxxvii, p. 143; Mineralogical Magazine, 1908, vol. xv, p. 18. Hydrated zinc phosphate, $Zn_3P_2O_8 \cdot 4H_2O$, dimorphous with hopeite, forming divergent groups of colourless, platy, anorthic crystals, resembling hemimorphite in appearance. It is found with tarbuttite ($Zn_3P_2O_8 \cdot Zn(OH)_2$; L. J. Spencer, 1907; 4th list) at Broken Hill, North-Western Rhodesia.

Paramontmorillonite. A. Fersmann, 1908. Bull. Acad. Sci. Saint-Pétersbourg, ser. 6, vol. ii, p. 264 (Paramontmorillonit), p. 656 (Парамонтмориллонить). A fibrous mineral placed with pilolite ('mountain-leather') in the palygorskite group; its composition, $H_{12}Al_2Si_4O_{17}$, is near to that of montmorillonite.

Parasepiolite. A. Fersmann, 1908. Bull. Acad. Sci. Saint-Pétersbourg, ser. 6, vol. ii, p. 263 (Parasepiolit), p. 657 (Парасепіолитъ). A fibrous mineral placed in the palygorskite group; its composition, $H_8Mg_2Si_3O_{12}$, is near to that of sepiolite.

Paratooite. D. Mawson and W. T. Cooke, 1907. Trans. Roy. Soc. South Australia, vol. xxxi, p. 68. An insoluble residue of bird-guano, consisting mainly of hydrated aluminium and ferric phosphate, but of variable and indefinite composition. Found on the top of an isolated rock near Paratoo railway siding in South Australia.

Pentahydrocalcite. P. N. Čirvinskij (Tschirwinsky), 1906. Ann. Géol. Min. Russie, vol. viii, p. 241 (Пентагидрокальцитъ), p. 245 (Pentahydrocalcit). Hydrated calcium carbonate, $CaCO_3 \cdot 5H_2O$, occurring as a mould-like encrustation on chalk-marl near Nova-Alexandria, govt. Lublin, Russian Poland. *See* Lublinite and Trihydrocalcite.

Plancheite. A. Lacroix, 1908. Compt. Rend. Acad. Sci. Paris, vol. cxlvi, p. 724; Bull. Soc. franç. Min., vol. xxxi, p. 250 (planchéite).

A blue, fibrous copper silicate, $H_{10}Cu_{15}Si_{12}O_{44}$ or $H_2(CuOH)_8Cu_7(SiO_3)_{12}$ occurring with dioptase as botryoidal masses or fibrous veins in limestone at Mindouli, French Congo. Named after Mr. — Planche.

Plumboniobite. O. Hauser and L. Finckh, 1909. Ber. Deutsch. Chem. Ges., xlii, p. 2270; O. Hauser, ibid., 1910, xliii, p. 417 (Plumboniobit). A niobate resembling samarskite in composition, but containing some lead (PbO, 7·55 per cent.): formula $R''_2Nb_2O_7 . R'''_4(Nb_2O_7)_3$, where $R'' = Fe,Pb,UO,Ca$, and $R''' = Gd,Sm,Y,Al$. Occurs as dark brown to black, imperfectly crystalline (optically isotropic) masses, associated with pitchblende, in the mica mines at Morogoro, Uluguru Mountains, German East Africa.

Potash-oligoclase. J. P. Iddings, 1906. Rock Minerals, New York, p. 232. A lime-soda-microcline (anorthoclase) in which lime appears to form part of the potash-soda-felspar, the composition being nearly that of oligoclase with part of the soda replaced by potash. Occurs in the rhomb-porphyry of southern Norway and in the kenyte of Kilimanjaro, East Africa.

Pseudodeweylite. F. Zambonini, 1908. Atti R. Accad. Sci. Fis. Mat. Napoli, ser. 2, vol. xiv, No. 1, p. 84; Rend. R. Accad. Sci. Fis. Mat. Napoli, ser. 3, vol. xiv, p. 148. A hydrated magnesium silicate, $Mg_3Si_2O_7 . 3H_2O$, from Chester Co., Pennsylvania, closely resembling deweylite, but differing slightly in composition (deweylite being $Mg_4Si_3O_{10} . 6H_2O$).

Pseudojadeite. A. W. G. Bleeck, 1907. Zeits. prakt. Geol., Jahrg. xv, p. 353; Rec. Geol. Survey India, 1908, vol. xxxvi, p. 267. Some of the material collected as jadeite from the jadeite quarry in Upper Burma was afterwards found on examination to be albite. Compare Jadeolite.

Pseudo-pirssonite. E. Stolley, 1909. Medd. Dansk Geol. For., No. 15, p. 361 (Pseudo-Pirssonit). Pseudomorphs, resembling pseudogaylussite, found in the alum-shales of Cambrian age on the island of Bornholm, Denmark. In a postscript (p. 368) it is suggested that the original mineral of these pseudomorphs may have been struvite rather than pirssonite, and the name pseudo-struvite (Pseudo-Struvit) is added.

Pseudo-struvite. E. Stolley, 1909. *See* Pseudo-pirssonite.

Pulleite. J. W. H. Adam, 1909. Zeits. prakt. Geol., Jahrg. xvii, p. 500 (Pulleit). Apatite in violet crystals of peculiar habit resembling

sheaf-like crystals of stilbite; from the pegmatite-veins at San Piero in Campo, Elba. Earlier described as a variety of apatite by R. Görgey (Centralblatt Min., 1909, p. 337). Named after Count J. G. Pullé of Elba.

Pyroxene-perthite, Pyroxene-microperthite, Pyroxene-cryptoperthite. W. Wahl, 1908. Öfvers. Finska Vet. Soc. Förh., 1906-7, No. 2, p. 19 (Pyroxenperthite, Pyroxenmikroperthite, Pyroxenkryptoperthite, plur.). Lamellar intergrowths of pyroxenes of different kinds, as with the felspars.

Quisqueite. D. F. Hewett, 1907. Quoted by W. F. Hillebrand, Amer. Journ. Sci., 1907, ser. 4, vol. xxiv, p. 141; Journ. Amer. Chem. Soc., 1907, vol. xxix, p. 1019. D. F. Hewett, Trans. Amer. Inst. Min. Engin., 1910, vol. xl, p. 286. A lustrous, black, brittle substance very like asphaltum in appearance, but containing much sulphur (S, 46½ per cent. with C, 43 per cent.) and only little hydrogen. It occurs with vanadium-ore (patronite) in the Quisque district, near Cerro de Pasco, Peru.

Rhönite. J. Soellner, 1907. Neues Jahrb. Min., Beil.-Bd. xxiv, p. 475 (Rhönit). X. Galkin, ibid., 1910, Beil.-Bd. xxix, p. 715. A dark brown, triclinic amphibole resembling aenigmatite in its microscopical characters, but differing from this in chemical composition, $(Ca,Na_2,K_2)_3Mg_4Fe''_2Fe'''_2Al_4(Si,Ti)_6O_{30}$. Occurs as a constituent of basaltic rocks in the Rhön Mountains and other localities. A. Lacroix (Bull. Soc. franç. Min., 1909, vol. xxxii, p. 325) describes an amphibole of the same kind, occurring in doleritic nephelinite at Puy de Barneire, Puy-de-Dôme, for which he gives the formula

$$(Na,K,H)_2Ca_8(Fe,Mg)_{15}(Al,Fe)_{16}(Si,Ti)_{21}O_{90}.$$

Rhomboclase. J. A. Krenner, 1891. Akadémiai Értesítő, Budapest, vol. ii, p. 96 (rhomboklas); Földtani Közlöny, Budapest, 1907, vol. xxxvii, pp. 204, 205; private letter from Professor Krenner, 1910. Hydrated acid ferric sulphate, $Fe_2O_3 . 4SO_3 . 9H_2O$, forming colourless rhombic plates with basal cleavage (hence the name, from *ῥόμβος* and *κλάω*), and occurring together with szomolnokite (q. v.) and other iron sulphates (kornelite, copiapite, coquimbite, &c.) at Szomolnok, Hungary.

The same compound, $(HO)_6Fe'''_2S_4O_{12} . 6H_2O$, has been prepared artificially by R. Scharizer, Zeits. Kryst. Min., 1901, vol. xxxv, p. 345; 1907, vol. xliii, p. 113.

Ricolite. A trade name for an impure serpentinous rock from New Mexico. Named from *rico* (Spanish), rich, in allusion to its rich green

colour. (G. P. Merrill, Stones for Building and Decoration, 2nd edit., 1897, p. 64.)

Rinneite. H. E. Boeke, 1908. Chemiker-Zeitung, Jahrg. xxxii, p. 1228; Centralblatt Min., 1909, p. 72; Neues Jahrb. Min., 1909, vol. ii, p. 19; Sitzungsber. Akad. Wiss. Berlin, 1909, p. 632 (Rinneit). O. Schneider, Centralblatt Min., 1909, p. 503. An anhydrous chloride of ferrous iron, potassium, and sodium, $FeCl_2 . 3KCl . NaCl$, occurring as large, lenticular masses in the Prussian salt deposits at Nordhausen and Hildesheim. It is clear and colourless, but quickly becomes yellow on exposure to the air. Rhombohedral crystals are occasionally found in the coarsely granular aggregates, and have also been prepared artificially. Named after Professor Fritz Rinne, of Kiel.

Risörite. O. Hauser, 1908. Zeits. Anorg. Chem., vol. lx, p. 230 (Risörit). A preliminary description was given in Ber. Deutsch. Chem. Ges., 1907, vol. xl, p. 3118. A niobate (and titanate) of yttrium, occurring as glassy, optically isotropic masses at Risör, Norway.

Rizopatronite. J. J. Bravo, 1906. [Informaciones y Memorias Soc. Ingen. Lima, vol. viii, p. 171; Bol. Soc. Ingen. Lima, August 1906], quoted by W. F. Hillebrand, Amer. Journ. Sci., 1907, ser. 4, vol. xxiv, p. 144; Journ. Amer. Chem. Soc., 1907, vol. xxix, p. 1022 (Rizo-Patronita). A synonym of patronite (D. F. Hewett, 1906; 4th list). A dark greenish-black vanadium sulphide, VS_4 or V_2S_9, occurring in vanadium-ore at Minasragra, near Cerro de Pasco, Peru. D. F. Hewett (Trans. Amer. Inst. Min. Engin., 1910, vol. xl, p. 287) suggests the formula $V_2S_5 + nS$. Named after Antenor Rizo Patrón, of the Huaraucaca smelting works near Cerro de Pasco.

Romanite. The same as rumänite (O. Helm, 1891), rumanite, roumanite (2nd list). An amber-like resin from Roumania (or Rumania; in Roumanian, România). (G. Munteanu-Murgoci, Gisements du succin de Roumanie, Asoc. Română Sci. Mem. Congres., Bucarest, 1903.)

Rosasite. D. Lovisato, 1908. Rend. R. Accad. Lincei, Roma, ser. 5, vol. xvii, sem. 2, p. 723. A fibrous, pale green, basic carbonate of zinc and copper, $5ZnCO_3 . 3CuCO_3 . 2CuO$, resembling aurichalcite, but differing from this in composition. From Rosas, Sardinia.

Samsonite. — Werner and — Fraatz, 1910. Centralblatt Min., 1910, p. 331 (Samsonit). Steel-black (red by transmitted light), 'monoclinic' crystals resembling miargyrite in appearance. In composition, $2Ag_2S . MnS . Sb_2S_3$, resembles pyrargyrite with part of the silver

replaced by manganese (Mn, 5·86 per cent.). Found with pyrargyrite and pyrolusite in the Samson mine, St. Andreasberg, Harz. The name samsonite has been used for a mining explosive.

Satelite. Trade-name for a serpentine cat's-eye from Tulare Co., California. Resembles chrysotile, but is harder and has a coarse splintery fracture. (D. B. Sterrett, Mineral Resources of the United States, for 1908, 1909, part ii, p. 839.)

Sefströmite. D. Mawson. Although unpublished by the author, the name appeared in 1907 on the labels and lists of dealers, being incorrectly spelt seffstromite. Supposed to be a vanadiferous variety of ilmenite. T. Crook (Mineralogical Magazine, 1910, vol. xv, p. 281) proves 'sefströmite' and 'davidite' (D. Mawson, 1906; 4th list) to be merely mixtures. Named after Nils Gabriel Sefström (1787–1845), the discoverer of vanadium.

Sitaparite. L. L. Fermor, 1908. Rec. Geol. Survey India, vol. xxxvii, p. 207; Mem. Geol. Survey India, 1909, vol. xxxvii, pp. lxvii, 49. A dark bronze-grey, crystalline, and cleavable mineral resembling vredenburgite (q. v.) in appearance, but differing from this in being only slightly magnetic. Formula perhaps $9Mn_2O_3 . 4Fe_2O_3 . MnO_2 . 3CaO$. Occurs with manganese-ores at Sitapár, Chhindwára district, Central Provinces, India.

Spurrite. F. E. Wright, 1908. Amer. Journ. Sci., ser. 4, vol. xxvi, p. 547. J. E. Spurr and G. H. Garrey, Economic Geology, vol. iii, p. 707. A silicate and carbonate of calcium, $2Ca_2SiO_4 . CaCO_3$, forming granular masses with glistening surfaces and resembling crystalline limestone in appearance. It effervesces in dilute hydrochloric acid with the separation of gelatinous silica. The optical characters suggest monoclinic symmetry. Occurs with hillebrandite (q. v.) in contact-metamorphic limestone at Valardeña, Durango, Mexico. Named after Josiah Edward Spurr, of New York.

Stellerite. J. A. Morozewicz, 1909. Bull. Intern. Acad. Sci. Cracovie, 1909, p. 344 (stellerycie, Stellerit). Calcium alumo-hepta-silicate, $CaAl_2Si_7O_{18} . 7H_2O$. An orthorhombic zeolite, resembling stilbite, found in diabase-tuff from the Komandor Islands, Bering Sea. Named after Georg Wilhelm Steller (1709–1746), the discoverer of the Komandor Islands.

Szomolnokite. J. A. Krenner, 1891. Akadémiai Értesítő, Budapest, vol. ii, p. 96 (szomolnokit); Földtani Közlöny, Budapest, 1907, vol.

xxxvii, pp. 204, 205; private letter from Professor Krenner, 1910. Hydrated ferrous sulphate, $FeSO_4 . H_2O$, forming yellowish or brownish, monoclinic pyramids isomorphous with kieserite ($MgSO_4 . H_2O$). Occurs with rhomboclase (q. v.) and other iron sulphates (kornelite, copiapite, coquimbite, &c.) at Szomolnok (German, Schmöllnitz), Hungary.

Tantalum. P. Walther, 1909. Nature, London, vol. lxxxi, p. 335. W. von John, ibid., 1910, vol. lxxxiii, p. 398. A bright, greyish-yellow crystalline powder from gold-washings in the Urals, containing Ta 98·5 per cent., Nb 1·5 per cent. The crystalline grains have been determined to be cubic by C. O. Trechmann. Found also in the Altai Mountains.

Taramellite. E. Tacconi, 1908. Rend. R. Accad. Lincei, Roma, ser. 5, vol. xvii, sem. 1, p. 810; Centralblatt Min., 1908, p. 506; Riv. Min. Crist. Italiana, 1909, vol. xxxix, p. 26. A basic meta-silicate, $Ba_4Fe''Fe'''_4Si_{10}O_{31}$ or $Ba_4Fe''(Fe'''O)Fe'''_3(SiO_3)_{10}$. Occurs as brownish-red, radially fibrous aggregates or as thin veins penetrating magnetite and iron-pyrites in the granular limestone of Candoglia, Piedmont. It is optically biaxial, strongly pleochroic, and probably orthorhombic. Named after Torquato Taramelli, professor of geology in the University of Pavia.

Tawmawite. A. W. G. Bleeck, 1907. Zeits. prakt. Geol., Jahrg. xv, p. 354 (Tawmawit); Rec. Geol. Survey India, 1908, vol. xxxvi, p. 269. A dark green, chromiferous (Cr_2O_3, 11·16 per cent.) variety of epidote, found as massive fragments in the jadeite quarry at Tawmaw in Upper Burma.

Trihydrocalcite. P. N. Čirvinskij (Tschirwinsky), 1906. Ann. Géol. Min. Russie, vol. viii, p. 241 (Тригидрокальцитъ), p. 245 (Trihydrocalcit). Hydrated calcium carbonate, $CaCO_3 . 3H_2O$, occurring as a mould-like encrustation on chalk-marl near Nova-Alexandria, govt. Lublin, Russian Poland. *See* Lublinite and Pentahydrocalcite.

Truffite. E. Dumas, 1876. Statistique géologique, minéralogique, &c., du Département du Gard, Paris, &c., 1876, vol. ii, pp. 431, 433 (not p. 491). A fibrous lignite which when struck emits an odour like that of truffles (French, truffe); it occurs as large, nodular masses, associated with ordinary lignite, in Cretaceous (Turonian) limestone at Pont-Saint-Esprit, dep. Gard. A. Lacroix (Minéralogie de la France, 1909, vol. iii, pp. 436, 509) describes it as a fetid, fibrous calcite.

Turanite. K. A. Nenadkevič, 1909. Bull. Acad. Sci. Saint-Petersbourg, ser. 6, vol. iii, p. 185 (Турашитъ). Hydrated copper vanadate,

$5CuO . V_2O_5 . 2H_2O$, forming compact, spongy, or radially fibrous aggregates and reniform crusts of an olive-green colour. Occurs with alaite (q. v.) in cavities in malachite and limestone near the Alai Mountains in the Turan district, Russian Central Asia.

Uhligite. O. Hauser, 1909. Zeits. Anorg. Chem., vol. lxiii, p. 342 (Uhligit). Bright, black octahedra, at first thought to be perovskite, but found to have the composition $5Ca(Zr,Ti)_2O_5 . Al_2TiO_5$; and thus regarded as an aluminous zirkelite with titanium predominating over zirconium: [zirkelite is, however, rhombohedral and not cubic]. Collected by Dr. Carl Uhlig from a metamorphosed nepheline-rock in the Great Rift Valley in German East Africa.

Vashegyite. K. Zimányi, 1909. Math. és természettudományi Értesítő, Budapest, vol. xxvii, p. 64 (Vashegyit); Zeits. Kryst. Min., xlvii, p. 53. A basic aluminium phosphate, $4Al_2O_3 . 3P_2O_5 . 30H_2O$, occurring as compact, dull white masses, resembling meerschaum in appearance, in the iron mine of Vashegy, comitat Gömör, Hungary.

Vedrite. Trade-name for an ornamental stone of a rich chrome-green colour, found as large blocks on the south bank of the North Kaap river, near Kaap Station, South Africa. The stone contains chrome-muscovite (fuchsite) and some argillaceous material. (G. F. Kunz, Mineral Industry, New York, for 1907, 1908, vol. xvi, p. 810.)

Villiaumite. A. Lacroix, 1908. Compt. Rend. Acad. Sci. Paris, vol. cxlvi, p. 215. Bull. Soc. franç. Min., vol. xxxi, p. 50. Sodium fluoride, occurring as a primary constituent in nepheline-syenite from the Los Islands, West Coast of Africa. The small crystals are tetragonal (pseudo-cubic) with three perfect cleavages at right angles, a deep carmine colour, and strong pleochroism. The mineral is soluble in water. Named after Mr. — Villiaume, who collected the material.

Vorobyevite. V. I. Vernadsky, 1908. Trav. Musée Géol. Pierre-le-Grand, St.-Pétersbourg, vol. ii, p. 81; Bull. Acad. Sci. St.-Pétersbourg, ser. 6, vol. ii, p. 975 (Воробьевитъ, vorobyevite); abstract in Neues Jahrb. Min., 1909, vol. ii, p. 21 (Worobieffit, Vorobyevite). A variety of beryl containing caesium (Cs_2O, 3·1 per cent., also Li_2O, 1·39 per cent.), in composition very like the beryl from Hebron, Maine, analysed by H. L. Wells (1892). White crystals of short prismatic habit from the Urals. Named in memory of Viktor Ivanovič Vorobyev (В. И. Воробьевъ) (1875–1906), by whom the material had been examined crystallographically. The name (worobewite) is also applied by A. Lacroix (Bull. Soc.

franç. Min., 1910, vol. xxxiii, p. 44) to tabular crystals of rose-coloured and colourless beryl, rich in alkalis, from Madagascar.

Vredenburgite. L. L. Fermor, 1908. Rec. Geol. Survey India, vol. xxxvii, p. 200; Mem. Geol. Survey India, 1909, vol. xxxvii, pp. lxvi, 42. A bronze-grey, crystalline, and cleavable mineral, which is strongly magnetic and sometimes with polarity. $3Mn_3O_4 . 2Fe_2O_3$. From the manganese-ore deposits of Central Provinces and Madras, India. Named after Ernest Watson Vredenburg, of the Geological Survey of India.

Worobieffite. *See* Vorobyevite.

SYSTEMATIC CLASSIFICATION OF NEW MINERALS.[1]

Element.

Tantalum.

Sulphides.

Bravoite, $(Fe,Ni)\ S_2$.
Jordisite, colloidal MoS_2.
Quisqueite, [C and S].

Sulph-antimonite.

Samsonite, $2Ag_2S . MnS . Sb_2S_3$.

Haloids.

Villiaumite, NaF.
Orthobromite, AgCl, AgBr.
Ostwaldite, colloidal AgCl.
Rinneite, $FeCl_2 . 3KCl . NaCl$.

Oxides.

Metacristobalite, SiO_2.
Neslite, var. of opal.
Chromitite, $FeCrO_3$.
Vredenburgite, $3Mn_3O_4 . 2Fe_2O_3$.
Sitaparite, $9Mn_2O_3 . 4Fe_2O_3 . MnO_2 . 3CaO$.
Alaite, $V_2O_5 . H_2O$.
Ehrenwerthite, colloidal $Fe_2O_3 . H_2O$.
Kliachite, colloidal Al hydroxides.

Manganate.

Beldongrite, $6Mn_3O_5 . Fe_2O_3 . 8H_2O$.

Carbonates.

Cobaltocalcite, var. of calcite.
Lublinite, „ „
Pentahydrocalcite, $CaCO_3 . 5H_2O$.
Trihydrocalcite, $CaCO_3 . 3H_2O$.
Rosasite, $5ZnCO_3 . 3CuCO_3 . 2CuO$.
Brugnatellite, $Mg_6FeCO_{20}H_{21}$.
Spurrite, $2Ca_2SiO_4 . CaCO_3$.

Sulphates.

Natrochalcite, $Na_2SO_4 . Cu_4(OH)_2(SO_4)_3 . 2H_2O$.
Szomolnokite, $FeSO_4 . H_2O$.
Rhomboclase, $Fe_2O_3 . 4SO_3 . 9H_2O$.

Phosphates, &c.

Pulleite, var. of apatite.
Fermorite, $(Ca,Sr)_5F(As,P)_3O_{12}$.

[1] Only the more important names given in the preceding alphabetical list are here included.

Georgiadesite, $Pb_3(AsO_4)_2 . 3PbCl_2$.
Parahopeite, $Zn_3P_2O_8 . 4H_2O$.
Turanite, $5CuO . V_2O_5 . 2H_2O$.
Ferganite, $U_3(VO_4)_2 . 6H_2O$.
Vashegyite, $4Al_2O_3 . 3P_2O_5 . 30H_2O$.
Oxykertschenite,
$(Mn,Mg,Ca)O . 4Fe_2O_3 . 3P_2O_5 . 21H_2O$.

BORATES.

Hulsite, Hyd. borate, Fe,Sn.
Paigeite ,, ,, ,, ,,

TANTALATES, TITANATES, &c.

Arizonite, $Fe_2O_3 . 3TiO_2$.
Delorenzite,
$2FeO . UO_2 . 2Y_2O_3 . 24TiO_2$.
Plumboniobite,
$R''_2 Nb_2O_7 . R'''_4(Nb_2O_7)_3$.
Risörite, niobate (& Ti) of Y.
Uhligite, $5Ca(Zr,Ti)_2O_5 . Al_2TiO_5$.

SILICATES.

Aglaurite, var. of orthoclase.
Natronsanidine, ,,
Isomicrocline, var. of microcline.
Potash-oligoclase.
Carnegieite, or soda-anorthite.
Anemousite, var. of plagioclase.
Anophorite, var. of amphibole.
Juddite, ,, ,,
Linosite, ,, ,,
Nephritoid, ,, ,,
Rhönite, ,, ,,
Enstatite-augite.
Clinoenstatite, &c.
Pyroxene-perthite.
Alamosite, $PbSiO_3$.
Magnesium-pectolite.
Vorobyevite, var. of beryl with Cs.
Hawaiite, var. of olivine.
Tawmawite, var. of epidote with Cr.
Taramellite, $Ba_4Fe''Fe'''_4Si_{10}O_{31}$.
Didymolite, $2CaO . 3Al_2O_3 . 9SiO_2$.
Benitoite, $BaTiSi_3O_9$.
Joaquinite, sil. & tit. Ca, Fe.
Spurrite, $2Ca_2SiO_4 . CaCO_3$.
Hallerite, var. of paragonite.
Bityite, $8Al_2O_3 . 5\frac{1}{2}(Ca,Be)O .$
$1\frac{1}{2}Li_2O . 10SiO_2 . 7H_2O$.
Aloisiite, $(H_2,Na_2,Ca,Fe,Mg)_4SiO_6$.
Hillebrandite, $Ca_2SiO_4 . H_2O$.
Plancheite, $H_{10}Cu_{15}Si_{12}O_{44}$.
Paramontmorillonite, $H_{12}Al_2Si_4O_{17}$.
Parasepiolite, $H_8Mg_2Si_3O_{12}$.
Pseudodeweylite, $Mg_3Si_2O_7 . 3H_2O$.
Hydrothomsonite,
$(H_2,Na_2,Ca)Al_2Si_2O_8 . 5H_2O$.
Stellerite, $CaAl_2Si_7O_{18} . 7H_2O$.

HYDROCARBONS.

Asphaltite.
Impsonite.
Malthite.

INDEX TO THE AUTHORS OF MINERAL NAMES.

This index supplements and brings up to date the very useful index given at the end of A. H. Chester's 'A Dictionary of the names of minerals' (New York, 1896). It serves, at the same time, as an index to the series of five lists of new mineral names published in this Magazine (1897–1910), with the exception, however, that names already in Chester are omitted. On the other hand, a few earlier names omitted from Dana's 'System of Mineralogy' (6th edit., 1892) and Chester's 'Dictionary' are included.

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Hulsite (1908)
Paigeite (1908)
KOECHLIN (R.)
Natronkalisimonyit (1902)

KOENIG (G. A.)
Argento-domeykite (1903)
Keweenawite (1902)
Melanochalcite (1902)
Mohawk-algodonite (1902)
Mohawk-whitneyite (1900)
Semi-whitneyite (1902)
Stibio-domeykite (1900)
KOSMANN (H. B.)
Hydrocalcite (1892)
KRAUS (E. H.)
and REITINGER (J.)
Hussakite (1901)
KRAUSÉ (F. M.)
Weldite (1885)
KRENNER (J. A.)
Lorandite (1894)
Rhomboclase (1891)
Szechenyiite (1897)
Szomolnokite (1891)
KRETSCHMER (F.)
Moravite (1906)
Stilpnochlorane (1905)
KUBIERSCHKY (K.)
Vanthoffite (1902)
KUNZ (G. F.)
Azurlite (1907)
Azurchalcedony (1907)
Azurmalachite (1907)
Californite (1903)
Jadeolite (1908)
Moissanite (1905)
Tiffanyite (1895)
Utahlite (1895)

LACROIX (A.)
Bityite (1908)
Giorgiosite (1905)
Gonnardite (1896)
Grandidierite (1902)
Ktypeite (1898)
Metacristobalite (1909)
Palmierite (1907)
Picrocrichtonite (1900)
Plancheite (1908)
Pseudoboleite (1895)
Pseudochalcedonite (1900)
Villiaumite (1908)
—— and SCHULTEN (A. de)
Georgiadesite (1907)
LAGORIO (A.)
Lembergite (1895)
LANDSTRÖM (G.)
Gunnarite (1887)

LASPEYRES (H.)
Kosmochlor (1897)
LAWSON (A. C.)
Iddingsite (1893)
LEITH (C. K.)
Greenalite (1903)
LENHER (V.)
v. WEIDMAN (S.)
LEYMERIE (A. F. G. A.) [1801–1878]
Neslite (1846)
LIENAU (H.)
Lacroisite (1903)
Torrensite (1899)
Viellaurite (1899)
LIMUR (Comte de)
Landevanite (1895)
Micaultite (1883)
LINDGREN (W.) and HILLEBRAND (W. F.)
Coronadite (1904)
Morencite (1904)
LIVEING (E. H.)
Speculite (1903)
LOEWINSON-LESSING (F. J.)
Pseudopyrophyllite (1895)
LOSANITSCH (S. M.)
Alexandrolite (1894)
LOUDERBACK (G. D.)
Benitoite (1907)
Carlosite (1907)
Joaquinite (1909)
LOVISATO (D.)
Barium-heulandite (1897)
Rosasite (1908)
LUCZIZKY (W.)
Isomicrocline (1905)

MACIVOR (R. W. E.)
Schertalite (1902)
MACKENZIE (SIR G. S.) [1780–1848]
Hydrolite (1819)
MACLEOD (W. A.)
and WHITE (O. E.)
Johnstonotite (1900)
MAESTRE (A.)
Teruelite (1845)
MALLARD (E.) [1833–1894]
Cumengeite (1893)
MARCK (von der)
Calcistrontite (1882)
MARCKWALD (W.)
Rutherfordine (1906)
MARTENS (P.)
Schulzenite (1895)

MAWSON (D.)
Davidite (1906)
Sefströmite
—— and COOKE (W. T.)
Paratooite (1907)
MEISTER (A.)
Didymolite (1908)
MELLOR (J. W.)
Clayite (1909)
MELNIKOV (M. P.)
Loranskite (1896)
MERWIN (H. E.)
v. PALACHE (C.)
MILLOSEVICH (F.)
Cobaltocalcite (1910)
MOROZEWICZ (J. A.)
Beckelite (1904)
Lagoriolite (1898)
Stellerite (1909)
MOSES (A. J.)
Eglestonite (1903)
Montroydite (1903)
MÜNSTER (C. A.)
Staalerts (1892)
MUNTEANU-MURGOCÍ (G.)
Lotrite (1900)
MUTHMANN (W.) and SCHRÖDER (E.)
Grünlingite (1897)

NAUMANN (C. F.) [1799–1873]
Serpentin-Asbest (1850)
NAUPERT (A.)
and WENSE (W.)
Kaliastrakanite (1893)
Sulfoborite (1893)
NAVARRO (F. L.) *v.* FERNÁNDEZ NAVARRO (L.)
NENADKEVIČ (K. A.)
Alaite (1909)
Turanite (1909)
NIKITIN (W.)
v. FEDOROV (E. S.)

OFF (H.)
v. RICHMOND (H. D.)
OSMOND (F.)
Cementite (1895)

PALACHE (C.)
Crossite (1894)
—— and MERWIN (H. E.)
Alamosite (1909)
—— and WARREN (C. H.)
Natrochalcite (1908)

PALMER (C.)
Arizonite (1909)
PANTZ ( )
Zeyringite (1811)
PAUL (M.) *v.* CALDERÓN (S.)
PEARCE (F.) *v.* DUPARC (L.)
PECKHAM (S. F.)
Mayberyite (1895)
Parianite (1895)
PELIKAN (A.)
Zeophyllite (1902)
PENFIELD (S. L.) [1856–1906]
Arsenpolybasite (1896)
Fluor-herderite (1894)
Graftonite (1900)
Hydro-fluor-herderite (1894)
Pearceite (1896)
—— and FOOTE (H. W.)
Bixbyite (1897)
Clinohedrite (1898)
Rœblingite (1897)
—— and JAMIESON (G. S.)
Tychite (1905)
—— and WARREN (C. H.)
Glaucochroite (1899)
Hancockite (1899)
Leucophœnicite (1899)
Nasonite (1899)
v. HILLEBRAND (W. F.)
PETERSON (C. A.)
Nigrite (1899)
PETTERD (W. F.)
Bellite (1905)
Dundasite (1893)
Heazlewoodite (1896)
Histrixite (1902)
Pelionite (1894)
Sclerospathite (1902)
PICHLER (A.)
Kochenite (1868)
PIESZCZEK (E.)
Beckerite (1880)
Stantienite (1880)
PITTMAN (E. F.)
Kalgoorlite (1898)
Willyamite (1893)
PONI (P.)
Badenite (1900)
Brostenite (1900)
Moldavite (1900)
POPOV (S. P.)
Kertschenite (1906)
Oxykertschenite (1907)
Paravivianite (1906)
Tamanite (1903)
POTONIÉ (H.)
Denhardtite (1905)
PRATT (J. H.)
Mitchellite (1889)
Pirssonite (1896)
—— and FOOTE (H. W.)
Wellsite (1897)
v. HIDDEN (W. E.)
PRIOR (G. T.)
Teallite (1904)
—— and COOMARASWAMY (A. K.)
Serendibite (1902)
—— and SMITH (G. F. H.)
Fermorite (1910)
—— and SPENCER (L. J.)
Iodembolite (1902)
v. HUSSAK (E.)
PRITCHARD (G. B.)
Mooraboolite (1901)

RAMSAY (W.)
Wiikite
—— and HACKMAN (V.)
Lamprophyllite (1894)
REINISCH (R.)
Astrolite (1904)
REITINGER (J.)
v. KRAUS (E. H.)
RENAULT (B.) *v.* BERTRAND
REUNING (E.)
Magnesium-pectolite (1907)
RICHARDS (J. W.)
Ledouxite (1901)
RICHMOND (H. D.) and OFF (H.)
Johnsonite (1892)
Masrite (1892)
RINNE (F.)
Arsensulfurite (1902)
Klinoaugite (1900)
Koenenite (1902)
Metadesmine (1897)
Metaheulandite (1899)
Metakalkuranit (1901)
Metakoenenite (1902)
Metakupferuranit (1901)
Metascolezite (1894)
Orthoaugite (1900)
Sulfurite (1902)
ROE (A. D.)
Hampdenite (1906)
ROGERS (A. F.)
Cuprogoslarite (1899)
ROSENBUSCH (H.)
Aegirine-augite (1892)
Beryllium-humite (1905)
Cerepidote (1905)
Glaucamphibole (1898)
Ilmenitglimmer (1905)
Magnesium-diopside (1905)
Palaeoleucite (1905)
Pseudomeionite (1902)
Titaneisenglimmer (1885)
RUSKIN (J.) [1819–1900]
Greenite (1884)

SACHS (A.)
Anapaite (1902)
Kleinite (1905)
SAMOJLOV (J. V.)
Beresowite (1897)
Orthobromite (1906)
SCACCHI (A.) [1810–1893]
Euchlorine (1884)
SCHALLER (W. T.)
Boothite (1903)
Ferripurpurite (1907)
Ferroaxinite (1909)
Manganipurpurite (1907)
Manganoaxinite (1909)
v. GRATON (L. C.)
HILLEBRAND (W. F.)
KNOPF (A.)
SCHARIZER (R.)
Ferropallidite (1903)
Ferrorömerite (1903)
Zinc-römerite (1903)
SCHNEIDER (O.)
Otavite (1906)
SCHNEIDER (R.)
Barracanite (1895)
Cupropyrite (1895)
SCHRÖDER (E.)
v. MUTHMANN (W.)
SCHULTEN (A. de)
v. LACROIX (A.)
SCHULZE (E.)
Pilite (1895)
SCHULZE (H. O.) [1853–1891]
Cuproiodargyrite(1892)
SEDERHOLM (J. J.)
Maltesite (1896)
SJÖGREN (H.)
Celsian (1895)
Mauzeliite (1895)
Natron-richterite (1892)
Potash-richterite (1895)
Soda-berzeliite (1895)
Soda-richterite (1892)
Tilasite (1895)

SMITH (G. F. H.)
Paralaurionite (1899)
Paratacamite (1905)
v. PRIOR (G. T.)
SOELLNER (J.)
Rhönite (1907)
SOLLY (R. H.)
Baumhauerite (1902)
Bowmanite (1904)
Hutchinsonite (1904)
Lengenbachite (1904)
Liveingite (1901)
Marrite (1904)
Smithite (1905)
Trechmannite (1904)
SOMMERFELDT (E.)
Metanhydrite (1907)
SPENCER (L. J.)
Miersite (1898)
Parahopeite (1907)
Tarbuttite (1907)
v. PRIOR (G. T.)
STANTON (J. R.)
Mohawkite (1900)
STEVANOVIĆ (S.)
Antimon-luzonite (1903)
STOLLEY (E.)
Pseudo-pirssonite (1909)
Pseudo-struvite (1909)
STRANDMARK (J. E.)
Baryta-orthoclase (1904)
SUESS (F. E.)
Antiperthite (1905)

TACCONI (E.)
Paracelsian (1905)
Taramellite (1908)
TAYLOR (T. G.)
v. DAVID (T. W. E.)
TENNE (C. A.) [1851–1901]
Leonite (1896)
TERMIER (P.)
Neotantalite (1902)
THUGUTT (S. J.)
Natronanorthite (1895)
TSCHIRCH (A.)
and AWENG (E.)
Allingite (1894)
TSCHIRWINSKY
v. ČIRVINSKY
TURNER (W. H.)
Terlinguaite (1900)

TWELVETREES (W. H.)
Petterdite (1901)

USSING (N. V.)
Cryolithionite (1904)

VATIČ (N. S.)
Lublinite (1908)
VERNADSKY (V. I.)
Vorobyevite (1908)
VIDAL Y CARETA (F.)
Cubaite (1890)
Guanabaquite (1891)
VILLADA (M. M.)
Landerite (1891)
VIOLA (C.)
Fedorowite (1899)

WADA (T.)
Naegite (1904)
WADSWORTH (M. E.)
Beaconite (1893)
WAHL (W.)
Clinobronzite (1906)
Clinoenstatite (1906)
Clinohypersthene (1906)
Enstatite-augite (1906)
Pyroxene-perthite (1908)
WALTHER (P.)
Tantalum (1909)
WARREN (C. H.)
v. HIDDEN (W. E.)
PALACHE (C.)
PENFIELD (S. L.)
WASHINGTON (H. S.)
Linosite (1908)
—— and WRIGHT (F. E.)
Anemousite (1910)
Carnegieite (1910)
WATITSCH *v.* VATIČ.
WEIDMAN (S.)
Irvingite (1907)
—— and LENHER (V.)
Marignacite (1907)
WEINSCHENK (E.)
Batavite (1897)
Fuggerite (1897)
Klinozoisite (1896)
Natron-phlogopite (1901)
WELLS (D. A.)
Crenite (1852)

WENSE (W.)
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WERNER ( ) and FRAATZ
Samsonite (1910)
WHITE (O. E.)
v. MACLEOD (W. A.)
WHITE (W. P.)
v. ALLEN (E. T.)
WINCHELL (A. N.)
Pigeonite (1900)
Pseudomesolite (1900)
WINCHELL (H. V.)
Mesabite (1893)
WINTHER (C.)
Britholite (1900)
Schizolite (1900)
WOLFF (F. von)
Aegirine-hedenbergite (1904)
Natronsanidine (1904)
WOLFF (J. E.)
Hardystonite (1899)
Zinc-schefferite (1900)
WRIGHT (F. E.)
Hillebrandite (1908)
Spurrite (1908)
v. WASHINGTON (H. S.)
WÜLFING (E. A.)
Geolyte (1900)

ZAMBONINI (F.)
Delorenzite (1908)
Melite (1899)
Müllerite (1899)
Pseudodeweylite (1908)
Pseudophillipsite (1902)
Strüverite (1907)
ZEMJATČENSKIJ (P. A.)
Hydrogoethite (1889)
Lardite (1889)
Silicomagnesiofluorite (1906)
ZEPHAROVICH (V. von) [1830–1890]
Paragite (1873)
ZIMÁNYI (K.)
Vashegyite (1909)
ZINCKEN (J. C. L.) [1790–1862]
Rosenite (1835)
ZIRKEL (F.)
Parorthoclase (1893)
ZUCKSCHWERDT (S.)
Langbeinite (1891)

OBITUARIES.

Émile Bertrand (1844–1909).

Émile Bertrand was a Corresponding Member of the Crystallological Society, becoming an Honorary Member of the Mineralogical Society with the amalgamation of the two societies in 1883. He was one of the founders of the French Mineralogical Society, and twice its president. Coming of a wealthy family, he spent some years in travel; and in 1869 he attended the Paris School of Mines, with 'une véritable passion pour la Minéralogie'. It was in 1872 that he commenced his series of researches in mineralogy, but unfortunately his brilliant scientific career was only too short. A bad state of health, which increased with years, ended in an almost complete loss of memory. Since 1888 only two papers have been published by him, the last being in 1897.

His work was two-sided in its character: he perfected instruments of research, and he used these instruments to advantage in determining the constants of minerals. Several improvements in the mineralogical microscope were made by him, one of which was the addition of the now well-known 'Bertrand lens' between the objective and the eye-piece for the purpose of showing interference-figures in convergent polarized light. He also designed a small, convenient form of refractometer. A large number of mineral species were re-examined, and it was his intention to pass in review all those which appeared doubtful. Friedelite was one of the species he discovered and described. His paper 'on the law of twinning and hemihedrism of leucophane' appeared in the Proceedings of the Crystallological Society.

An obituary notice, written by Professor G. Wyrouboff, together with a portrait and list of papers, sixty-one in number, has appeared in Bull. Soc. franç. Min., 1910, vol. xxxiii, pp. 117–124.

Maria Aristides Brezina (1848–1909).

Dr. Aristides Brezina was elected an Honorary Member of our Society in 1895. He was born at Vienna on May 4, 1848, dying there after a long and severe illness on May 25, 1909. He entered the Royal Mineralogical Collection at Vienna (k. k. Hofmineralien-Kabinet) as a pupil at the age of fourteen, and as an assistant at the age of twenty; and when this collection was transferred to the new Natural History Museum

(k. k. naturhistorisches Hofmuseum) in 1889 he was appointed director of the mineralogical and petrographical division, from which post he retired in 1896. During a portion (1874–92) of this period he also acted as teacher of crystallography in the University of Vienna. Besides studying at Vienna, he had also studied crystallography at Berlin and Paris, and graduated at Tübingen in 1872.

Much of his earlier work related to the crystallography of minerals and artificial compounds; and he described as new species the minerals herrengrundite, schneebergite, and strüverite. On the retirement of Professor Gustav Tschermak from the Mineral Cabinet in 1878 he took special charge of the extensive collection of meteorites, and he then commenced to devote himself with much zeal to the study of these bodies, more especially the meteoric irons. It is through his work in this direction that he is most widely known.

A fuller account of his life, together with a long list of his published works, is given by Dr. C. Hlawatsch in Verh. geol. Reichsanstalt, Wien, 1909, pp. 181–187.

Fredrik Johan Wiik (1839–1909).

Professor F. J. Wiik, an Honorary Member of this Society since 1880, died at Helsingfors on June 15, 1909. He was born in that city on December 16, 1839, graduated in 1865, and in 1877 was appointed Professor of Geology and Mineralogy in the University of Helsingfors, retiring with the title of Emeritus-Professor in 1898. His published work is not voluminous and relates almost exclusively to the geology and the minerals of his native country, though in 1893 he also propounded an elaborate crystallo-chemical theory of the silicates. The mineral wiikite, named in his honour by his successor, Professor Wilhelm Ramsay, is remarkable in containing a larger quantity of the rare element scandium (Sc_2O_3 1·17 per cent.) than any other known mineral.

Hilary Bauerman (1833–1909).

Although not a member of our Society, Professor Bauerman was always interested in our science. He was the first student entered at The Government School of Mines and of Science applied to the Arts' (now the Royal School of Mines), and he afterwards spent three years at the Freiberg Mining Academy. In 1856 he was appointed assistant geologist on the Geological Survey of Great Britain, and in 1858 was a joint-author of a catalogue of the rock specimens in the Museum of

Practical Geology. For nearly twenty years he was Professor of Metallurgy in the Ordnance College at Woolwich.

His textbooks on 'Systematic mineralogy' and 'Descriptive mineralogy' were published in 1881 and 1884 respectively, and he was the author of standard works on metallurgy. A favourite hobby of his was the construction of crystal-models by the folding of paper. By his will he left a considerable sum on trust, subject to a life interest, for the encouragement of the study of mineralogical science at the Royal School of Mines.

Obituary notices have appeared in several scientific and technical journals, and a portrait is given in the Mining Journal of December 18, 1909.

Felix Cornu (1882–1909).

Dr. F. Cornu was born at Prague on December 26, 1882, and spending most of his boyhood in the district of the Mittelgebirge in northern Bohemia, he became a keen collector of zeolites and other minerals. In 1902 he entered the University of Vienna, graduating there in 1906, and from 1904 acting as demonstrator under Professor F. Becke. In 1907 he was appointed assistant in mineralogy in the Royal Mining School at Leoben in Styria. Never very strong, he brought on by overwork a nervous breakdown from which he only partially recovered; and he died by his own hand during the night of September 22–23, 1909.

Although not twenty-seven years of age, he had accomplished more work than many investigators do in a full life-time. His capacity for work and his versatility seem indeed to have been extraordinary. The list of his notes and papers, from 1903 till the time of his death, includes no less than eighty-five titles, and papers from his pen still continue to appear. Although some of his notes appear to be trivial and to have been hastily prepared, there are many of his papers which indicate very careful work. It would have been much better, both for the individual and for the science, had he been advised to look always to the quality as well as the quantity of *published* work. Unfortunately the keen competition for posts in these days rather offers an inducement to work of this kind.

Many of Cornu's earlier papers were on the zeolites and rocks of the Bohemian Mittelgebirge; and one of his best pieces of work was on the 'micaceous zeolites', gyrolite, zeophyllite, and a new species reyerite. He also described the existence of regular contraction fissures in zeolites. In 1907, with the aid of a travelling scholarship from the University of

Vienna, he visited the zeolite localities of Scotland and the Faroe Islands. Later, he became interested in more general problems, one of which was the cause of the peculiar blue colour of rock-salt, and it was in this mineral that he discovered the phenomenon of piezo-pleochroism. More recently, he turned his whole attention, day and night, to the study of the colloidal forms of minerals, which appear to be of some importance in the products of weathering and in soils.

Hans Christian Albert Hauswaldt.

Dr. Hans Hauswaldt, a counsellor of commerce (Kommerzienrat) of Magdeburg, died on March 27, 1909. He possessed a private laboratory well equipped with instruments, in which he obtained a large number of beautiful photographs of the optical interference-phenomena of crystals and photo-micrographs illustrating various kinds of crystalline structure. Many of these photographs were published in his work 'Interferenz-Erscheinungen an doppeltbrechenden Krystallplatten im konvergenten polarisirten Licht' (Magdeburg: J. G. Hauswaldt, 1902, 1904, and 1907), the three portfolios of which contain a total of 185 magnificent quarto plates reproduced in black and white. In a posthumous publication, in conjunction with D. Vorländer, is given a series of nineteen plates of the interference-figures shown by liquid crystals (Abh. Leop. Carol. Akad. Halle, 1909, vol. xc).

REVIEWS.

Crystallography, an elementary manual for the laboratory. By Professor M. Edward Wadsworth. Pp. xvi [+ xx] + 299, with 25 double plates. (Philadelphia: J. J. McVey. 1909. Price $3.00).

This book is intended to give to students of geology and mining, as well as to prospectors, an idea of the forms of crystals, which will be of assistance to them in the determination of minerals in the field or laboratory. The detailed description of the forms of the six systems commences at p. 9 with the triclinic system, and ends at p. 147 with the isometric system. The student is then taken through the whole of this again three times in the succeeding chapters headed 'Crystallographic

symmetry', 'The thirty-two classes of crystals', and 'Crystallographic nomenclature'.

Much prominence is given (in heavy type) to the names of the different simple forms, and little is said of combinations of forms. The notations used include those of Weiss, Naumann, Dana, and Miller; the last being referred to as 'the Whewell-Grassman-Miller system as modified by Bravais'. There are very many points open to criticism. For example, in the triclinic system there is a confusion between hemi-prisms or hemi-domes and hemihedral forms; and it is quite incorrect to speak of tetartohedral forms in this system. Again, it is difficult to understand how a basal plane can be described as a 'vertical pinacoid'.

The numerous figures (612 in number), instead of being conveniently placed in their appropriate places in the text, are printed on flimsy paper and placed together towards the end of the volume; and reference to them is a matter of some difficulty. The detailed explanations of these plates occupy 59 pages of text. This arrangement is alone sufficient to prevent the book being recommended to students; and we cannot imagine that it will find much circulation outside the author's own classes.

Reviews of books very frequently end with a complaint of the paucity of the index. Here, however, we find an index extending over 35 pages, and we must confess that we have found this the most interesting (not to say amusing) portion of the volume. In one place in the text casual reference is made to emigrants from Russia, Poland, and Bohemia; in another place William Shakespeare, Ben Johnson [*sic*], Frederick Barbarossa, &c., are given as examples of binomial names: all these appear in the index, and the last of them under F. The long lists of the positive and negative forms of crystals are each allotted over a page; while under the index-entry 'Type, Nephelite' there are no less than eleven page-references, but there is no mention of the subject on most of the pages so quoted.

Das Radium und die Farben. Einwirkung des Radiums und ultravioletter Strahlen auf organische und anorganische Stoffe sowie auf Mineralien. By Professor C. Doelter. Pp. viii + 133. (Dresden: Theodor Steinkopff. 1910. Price 4 Marks, bound 5 Marks.)

The author has carefully collected a vast number of isolated facts, to be found scattered through scientific literature, respecting the changes in colour which minerals and various artificial substances undergo when they are exposed to the action of radiations of various kinds, including

ultra-violet rays, cathode rays, Röntgen rays, and the rays emitted by radium salts. To these he adds numerous observations of his own on a great variety of substances, and the results of experiments made by heating coloured materials in an atmosphere of oxygen, nitrogen, or carbon dioxide.

By simply allowing a substance to remain close to radium chloride for a few weeks or months marked changes in colour are frequently to be observed. For example, fluor-spar which has previously been decolorized by heating to a temperature of about 220° C., becomes bluish-green or sometimes bluish-violet; this colour gradually disappears after a few days, even if the specimen be kept in the dark. Most blue sapphires are soon changed to yellow or yellowish-brown under the influence of radium-rays: and the original blue colour may be restored by exposure to ultra-violet rays. Colourless topaz is changed to orange-yellow by the radium-rays; and many other gem-stones are affected, though not the artificially produced ruby and sapphire.

Such changes as these are discussed in connexion with the general and very complex subject of the coloration of minerals, but it is evident that much more work requires to be done before any far-reaching conclusions can be drawn. The mysterious and especially interesting case of the blue coloration of rock-salt is considered at some length.

Spark spectra of the metals. By Charles E. Gissing, Rear-Admiral R.N. (retired). Pp. vii + 21, with 12 plates. 4to. (London: Baillière, Tindall and Cox. 1910. Price 7*s.* 6*d.* net.)

In a series of fifty black and white photographic reproductions, each six inches in length, are given the characteristic spark-spectra of the metals and of a few other elements. Tables of the wave-lengths of the principal lines are given, and a brief description of the apparatus used by the author is added. The illustrations and tables are intended to help in the identification of the metals present when metallic ores are examined by this method; but no examples are given of the spark-spectra of actual minerals. That this method may be of some value in the examination of minerals has been proved by the researches of W. N. Hartley and H. Ramage, and of the Comte A. de Gramont.

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118	6	*For* J. G. Stead *read* J. E. Stead.
180	13*	*For* $2UO_3$ *read* $2U_2O_3$.

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287	4*	*For* 39° 23′ *read* 39° 15′.
289		In Table II the distances from b = (010) should read for o (211) 60° 59′, N (221) 42° 11′, F (210) 50° 45′; from c = (001), s (142) 56° 46½′, n (121) 57° 39′, r (122) 38° 17′, t (342) 58° 57′, N (221) 60° 32′, p (111) 41° 30′, q (322) 45° 42′, o (211) 50° 2′, Q (311) 57° 38′; and the azimuth of F (210) should read 39° 15′.
300	20	*For* 2E *read* 2V.
336	21	*For* Baldomero mine *read* San Baldomero mine.
	22	*For* Sorato *read* Sorata.
338	8*	*For* father *read* brother.
343		Fig. 11, not Fig. 12, $f\{\bar{1}11\}$ twinned on (111).
392		Column V of Table should read P_2O_5 30·20, Al_2O_3 32·67, SrO 19·25, BaO 4·18, H_2O 12·53, F 2·01.
403	20	*For* higher *read* lower.
420		Under Binnenthal, *for* xxxiv, xliii *read* xxxix, xlii.
421		*For* Dufret *read* Dufet.
423		Under Obituaries, *for* Dufret *read* Dufet.

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iii	7	*For* Allen *read* Allan.
73	9	*For* equations (5) *read* equations (25).
75	2*	*For* equations (9), (1) *read* equations (9), (10).
114	17-18	*For* pneumatolitic *read* pneumatolytic.

* From bottom of page.